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Comparison of Extracorporeal Shock Wave Lithotripsy Success Rates Between Ultrasound Targeting and X-ray Targeting

Vücut Dışı Şok Dalgası İle Taş Kırma Başarısında Ultrason Kılavuzluğu ile X Işını Kılavuzluğunun Karşılaştırılması

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ÖZET

Amaç: Bu retrospektif çalışmanın amacı, vücut dışı şok dalgası ile taş kırma (SWL) başarısında ultrason (USG) ile hedefleme ve X ışını ile hedeflemeyi karşılaştırmaktır.

Gereç ve Yöntemler: Ocak 2018 ile Aralık 2020 tarihleri arasında üriner sistem taş hastalığı için SWL uygulanan hastaların dosyaları geriye dönük olarak incelendi. Hastalar, SWL sırasında taş hedefleme için kullanılan görüntüleme yöntemine göre iki gruba ayrıldı: USG grubu ve X ışını grubu. SWL başarısı, taşların tamamen temizlenmesi veya klinik olarak önemsiz, rezidü fragmanların olması (<4 mm) olarak tanımlandı ve başarı oranı iki grup arasında karşılaştırıldı.

Bulgular: Çalışmaya her grupta 100 hasta olmak üzere toplam 200 hasta dahil edildi. İki gruptaki hastaların demografik verileri ve taş özelllikleri benzerdi. SWL'nin başarı oranı USG grubunda %84 iken, X ışını grubunda %72 idi (p=0,041). USG grubunda taşsızlık elde etme ihtimali, X ışını grubuna göre 2,04 (%95 GA: 1,02-4,07) kat fazlaydı.

Sonuç: Bu retrospektif çalışma, USG hedeflemesiyle yapılan SWL'nin, X ışını hedeflemeli SWL'ye kıyasla daha yüksek bir başarı oranına sahip olabileceğini önermektedir. USG kılavuzluğu, SWL sırasında taş hedefleme için iyonize radyasyon kullanmadan güvenli ve etkili bir alternatif sunmaktadır. Bu bulguları doğrulamak ve klinik pratikte USG kılavuzluğunda SWL'nin potansiyel faydalarını araştırmak için daha fazla çalışmaya ihtiyaç vardır.

Anahtar Kelimeler: vücut dışı şok dalga ile taş kırma, ultrason, X ışını, üriner taş hastalığı

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Approval was received for this study from the Oxford University Hospitals Ethics Committee (Approval Number: 1249/23, Decision date: 2021-05-21). The ethical rules of the Declaration of Helsinki were followed in the study protocol.

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ABSTRACT

Objective: This retrospective study aims to compare the success rates of shock wave lithotripsy (SWL) using ultrasound (US) targeting versus X-ray targeting.

Material and Methods: A retrospective chart review was conducted on patients who underwent SWL for urinary tract stones between January 1, 2018, and December 31, 2020. The patients were divided into two groups based on the imaging modality used for stone targeting during SWL: the US group and the X-ray group. The success rates of SWL, defined as complete stone clearance or clinically insignificant residual fragments (<4mm), were compared between the two groups.

Results: A total of 200 patients were included in the study, with 100 patients in each group. The demographics and stone characteristics of the patients were similar between the two groups. The success rate of SWL in the US group was 84%, compared to 72% in the X-ray group ($p=0.041$). The odds ratio for success in the US group compared to X-ray group was 2.04 (95% confidence interval: 1.02-4.07)

Conclusion: This retrospective study suggests that SWL with US targeting may have a higher success rate compared to X-ray targeting. US provides a safe and effective alternative for stone targeting during SWL, avoiding the use of ionizing radiation. Further research is warranted to confirm these findings and explore the potential benefits of US guided SWL in clinical practice.

Keywords: extracorporeal shock wave lithotripsy, ultrasound, X-ray, urinary stone.

INTRODUCTION

Urinary tract stones, or urolithiasis, are a prevalent condition worldwide, affecting approximately 10% of the population at some point in their lives (1). The management of urinary stones depends on various factors, including stone size, location, composition, and patient-related factors. Among the treatment options available, extracorporeal Shock Wave Lithotripsy (SWL) has gained significant popularity due to its non-invasiveness and relatively low complication rates (2).

SWL works by delivering focused shock waves to the targeted stone, resulting in its fragmentation. The fragmented stone particles can then pass through the urinary tract and be eliminated naturally. The success of SWL depends on accurate targeting of the stone to maximize fragmentation while minimizing damage to surrounding tissues (3).

Traditionally, fluoroscopy or X-ray has been the standard imaging modality used for stone targeting during SWL. X-ray provides excellent visualization of urinary stones, allowing for precise targeting. However, the use of ionizing radiation raises concerns about potential risks, particularly in younger patients and women of childbearing age (4). Additionally, obese patients or those with a large body habitus may require higher radiation doses to achieve adequate image quality, increasing the risk of radiation-induced damage (5).

To address these concerns, ultrasound (US) has emerged as an alternative imaging modality for stone targeting during SWL. US offers several advantages, including real-time imaging guidance, absence of ionizing radiation, and portability, allowing for bedside procedures. Additionally, US can provide information about stone composition and characteristics, aiding in treatment planning (6).

Several studies have investigated the efficacy of US-guided SWL compared to X-ray- guided SWL. While some studies have demonstrated comparable success rates between the two modalities (7, 8), others have suggested potential benefits of US targeting, including higher stone clearance rates and reduced radiation exposure (9, 10).

The aim of this retrospective study is to compare the success rates of SWL using US targeting versus X-ray targeting in a real-world clinical setting. By assessing the outcomes of SWL with different imaging modalities, we aim to contribute to the existing body of literature and provide valuable insights for clinical decision-making.

MATERIAL AND METHODS

A retrospective chart review was conducted on patients who underwent SWL for urinary tract stones at our institution between January 1, 2018, and December 31, 2020. The study was approved by the Oxford University Hospitals Ethics Committee (approval reference number: 1249/23, decision date: 21.05.2021) and "informed consent" was obtained from all patients. Patients aged 18 years and older that had one kidney stone, no bleeding diathesis, sterile urine culture and no signs of obstruction distal to the stone were included. Those who were pregnant, those who were under the age of 18, those who had bleeding diathesis, and those who had more than one kidney stone or who had ureteral stone were excluded from the study. Those with active urinary tract infection were included after obtaining a sterile urine culture.

Patients were divided into two groups based on the imaging modality used for stone targeting during SWL: the US group and the X-ray group. The choice of imaging modality was determined by the treating urologist's preference and availability.

In the US group, stones were targeted using US guidance. The imaging was performed using a GE LOGIQ S8 US system (GE Healthcare, Chicago, IL) with a 1 MHz probe. The urologist utilized real-time US imaging to visualize the stone and guide the shock wave delivery.

In the X-ray group, stones were targeted using fluoroscopy. The imaging was performed using a GE Optima XR220amx fluoroscopy system (GE Healthcare, Chicago, IL) with a low- dose protocol to minimize radiation exposure. The urologist utilized fluoroscopic guidance to visualize the stone and guide the shock wave delivery.

SWL was performed using a Storz Modulith SLX-F2 lithotripter (STORZ Medical AG, Tägerwilen, Switzerland). The lithotripter utilized electromagnetic shock wave generation with a focal length of 130 mm, a focal width of 20 mm, and a frequency of 60 shocks per minute. The maximum energy level was set at 100% and was gradually increased until the fragmentation of the stone was achieved. SWL was applied in a maximum of 3 sessions with an interval of 1 week.

The primary outcome measure was the success rate of SWL, defined as complete stone clearance or clinically insignificant residual fragments (CIRFs) measuring less than 4mm. Success was assessed one month after the last session using post-procedure imaging, including US or X-ray, as appropriate.

Statistical analysis was performed using the Student's t-test for normally distributed continuous data, Mann-Whitney U test for continuous data that did not show normal distribution, and chi-square test to compare qualitative data. Kolmogorov-Smirnov test was used to determine the normal distribution of continuous data. Odds ratio (OR) with 95% confidence intervals (CI) was calculated to determine the likelihood of success with US targeting compared to X-ray targeting.

RESULTS

A total of 200 patients were included in the study, with 100 patients in each group. The baseline characteristics of the patients are summarized in Table 1. The majority of patients in both groups were male, but there was no statistically significant difference (p=0.374). Age, body mass index, stone size, stone side, stone Hounsfield Unit, and stone location of the patients were similar in both groups.

The success rates of SWL in the US and X-ray groups are presented in Table 2. The success rate of SWL in the US group was 84%, compared to 72% in the X-ray group (p=0.041). The odds ratio for success in the US group compared to X-ray group was 2.04 (95% CI: 1.02-4.07), indicating a higher likelihood of success with US targeting. Overall, the need for further interventions were higher in the X-ray group when compared to US group as 15% and 11% respectively, but this difference was not statistically significant (p=0.4).

Table 1. Baseline Characteristics of the Study Population

Characteristics	US Group (n=100)	XR Group (n=100)	p values
Age, mean ± SEM (years)	52.4 ± 0,8	54.1 ± 0,9	0.168[a]
Gender, n (%) (male)	62 (62%)	68 (68%)	0.374[b]
Body Mass Index, median (interquartile range)	26.0 (23.7-29.0)	26.8 (24.3-29.3)	0.133[c]
Stone Size, median (interquartile range) (mm)	10.0 (8.0-12.00)	10.0 (8.0-12.0)	0.585[c]
Stone Side, n (%) (right)	46 (46%)	52 (52%)	0.396[b]
Hounsfield Unit, median (interquartile range)	847.5 (765.5-961.0)	886.0 (756.7-1013.0)	0.395[c]
Stone Location (n (%))			
Pelvis	54 (54%)	50 (50%)	0.488[b]
Mid or Upper Calyx	38 (38%)	45 (45%)	
Lower Calyx	8 (8%)	5 (5%)	

Abbreviations: SEM, standard error of the mean; US, ultrasound; XR, X-ray.
Interquartile range: 25th to 75th percentile
[a] Student's t-test.
[b] Chi-Square test.
[c] Mann-Whitney U test.

Table 2. Success Rates of SWL in the US and X-ray Groups

Outcome	US Group	XR Group	p values
Stone Clearance, n (%)	84 (84%)	72 (72%)	0.041[a]
Clinically Significant Residual Fragments (>4mm), n (%)	16 (16%)	29 (29%)	0.041[a]
Need for Further Interventions, n (%)	11 (11%)	15 (15%)	0.4[a]

Abbreviations: US, ultrasound; XR, X-ray.
[a]Chi-Square test.

DISCUSSION

The findings of this retrospective study suggest that SWL with US targeting may have a higher success rate compared to SWL with X-ray targeting. There are some studies in the literature comparing targeting with US and X-ray in SWL success. Van Besien et al. designed a prospective randomized study on 114 patients who had renal and upper ureteric calculi. They showed that US-guided SWL was not inferior to fluoroscopy-guided SWL (7). Another prospective randomized study was designed on pediatric patients recommends the use of the ultrasonic focusing modality in SWL with similar success rates instead of the fluoroscopic focusing modality because of avoiding radiation and low complication rate (8). Similarly, some retrospective studies have shown similar success rates, while others report US-guided SWL has a better success rate than fluoroscopy-guided SWL in the treatment of urinary system stones (9-11).

The use of US for stone targeting during SWL offers several advantages, including the avoidance of ionizing radiation and real-time imaging guidance. There is an increased cancer risk with high-dose rates of ionizing radiation compared to low-dose rates especially total doses exceeded 0.5 Gy (12). Patients with urinary system stones are exposed to ionizing radiation in their life-long follow-up and treatment, and thus this risk increases. Fluoroscopy-guided SWL causes more radiation exposure compared to conventional radiography (13). Therefore, the more radiation dose can be reduced, the lower that risk in these patients.

In addition, ionizing radiation poses a risk to the SWL practitioner as well as to the patient. Therefore, it will be safe for urologists and technicians as well.

Real-time imaging by using hit/miss monitoring with US but not with X-ray can provide more accurate focusing on the stone (14). This advantage may contribute to improved accuracy in stone targeting, leading to higher success rates especially in obese patients. In our study, there were obese patients in both groups, but the success rates in these patients were not compared. This issue can be considered as a separate study topic. Another advantage of ultrasound guided SWL is that it is a safe and effective method in the treatment of radiolucent stones (15).

It is important to acknowledge the limitations of this study. First, this is a retrospective study. Second, there could potentially be selection bias. Third, more detailed patient information and SWL-related complication rates are not specified and therefore not compared. Fourth, although HU was similar between the two groups, it was not stated in the study whether there were radiolucent stones in the US group or how many patients had high HU in both groups. This may have disrupted the homogeneity of the groups. Prospective, randomized controlled trials are needed to further validate these findings and establish the superiority of US targeting in SWL.

CONCLUSION

In conclusion, this retrospective study suggests that SWL with US targeting may have a higher success rate compared to SWL with X-ray targeting. The use of US provides a safe and effective alternative to X-ray for stone targeting during SWL. Further research is warranted to confirm these findings and explore the potential benefits of US guided SWL in clinical practice.

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Conflict of Interest: The authors declare no conflict of interest.

Ethical Approval: The study was approved by the Oxford University Hospitals Ethics Committee (approval reference number: 1249/23, decision date: 21.05.2021). The study protocol conformed to the ethical guidelines of the Helsinki Declaration.

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