Original Article – Endourology

Risk factors predicting the need for urgent URS in patients undergoing SWL for proximal ureteral stones

Proksimal üreter taşı için SWL yapılan hastalarda acil URS gereksinimini tahmin eden risk faktörleri

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Abstract

Objective: To evaluate the clinical, anatomical, and stone-related factors in patients who underwent shock wave lithotripsy (SWL) for proximal ureteral stones and to identify the risk factors associated with the subsequent need for urgent ureteroscopy (URS).

Materials and Methods: Patients who underwent SWL for proximal ureteral stones were included in the study. Demographic and clinical characteristics, including age, body mass index (BMI), serum creatinine, white blood cell count, hemoglobin, and platelet count, were recorded. Stone characteristics and anatomic factors were determined using parameters obtained from non-contrast lower upper abdomen computed tomography scans: stone density (HU), stone diameter, renal pelvis urine density (HU), perirenal stranding, stone-skin distance, and ureteral wall thickness. Patients who underwent emergency URS were grouped. Logistic regression analysis was used to identify risk factors predicting the need for urgent URS in patients.

Results: Among the study population, 232 patients (83.8%) did not require urgent URS (Group 1), while urgent intervention was necessary in 45 patients (16.2%) (Group 2). Patients in the urgent URS group demonstrated a significantly higher body mass index (26 [24-27] vs. 25 [24-26] kg/m², $p = 0.002$). Non-contrast CT findings revealed that renal pelvis urine density and stone–skin distance were markedly greater in the URS group (13 [9-36] vs. 8 [6-11] HU, $p < 0.001$ and 12 [6-16] vs. 9 [7-13] cm, $p < 0.001$, respectively). Stone density was also higher among patients requiring URS (862 [784-1014] vs. 786 [665-956] HU, $p = 0.002$). In multivariable analysis, BMI (OR 1.245, 95% CI 1.025–1.512, $p = 0.028$), stone density (OR 1.003, 95% CI 1.001–1.004, $p = 0.002$), renal pelvis urine density (OR 1.032, 95% CI 1.009–1.055, $p = 0.006$), and stone–skin distance (OR 1.654, 95% CI 0.986–1.846, $p = 0.004$) remained as independent predictors.

Conclusion: BMI, stone density, renal pelvic urine density, and stone–skin distance parameters may serve as useful guidance when considering SWL for patients with proximal ureteral stones. Prospective studies with larger samples are needed to support the findings.
Keywords: SWL, urolithiasis, urgent URS, proximal ureteral stones

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Özet

Amaç: Proksimal üreter taşı nedeniyle SWL uygulanan hastalarda klinik, anatomik ve taşla ilişkili faktörleri değerlendirmek ve sonrasında acil URS ihtiyacıyla ilişkili risk faktörlerini belirlemek.

Gereçler ve Yöntemler: Proksimal üreter taşı nedeniyle SWL uygulanan hastalar çalışmaya dahil edildi. Yaş, vücut kitle indeksi, serum kreatinin, beyaz kan hücresi sayısı, hemoglobin ve trombosit sayısı gibi demografik ve klinik özellikler kaydedildi. Taş özellikleri ve anatomik faktörler, kontrastsız alt ve üst karın BT taramalarından elde edilen parametreler kullanılarak belirlendi: taş yoğunluğu (HU), taş çapı, renal pelvis idrar yoğunluğu (HU), perirenal kontaminasyon, taş-deri mesafesi ve üreter duvar kalınlığı. Acil URS uygulanan hastalar gruplandırıldı. Hastalarda acil URS ihtiyacını öngören risk faktörlerini belirlemek için lojistik regresyon analizi kullanıldı.

Bulgular: Çalışma popülasyonunda 232 hasta (%83,8) acil URS'ye (Grup 1) ihtiyaç duymazken, 45 hastada (%16,2) acil müdahale gerekti (Grup 2). Acil URS grubundaki hastalar anlamlı derecede daha yüksek vücut kitle indeksi (26 [24-27] – 25 [24-26] kg/m², p = 0,002) gösterdi. Kontrastsız BT bulguları, renal pelvis idrar yoğunluğunun ve taş-cilt mesafesinin URS grubunda belirgin şekilde daha yüksek olduğunu ortaya koydu (sırasıyla 13 [9-36] – 8 [6-11] HU, p < 0,001 ve 12 [6-16] – 9 [7-13] cm, p < 0,001). Taş dansitesi URS gerektiren hastalarda da daha yüksekti (862 [784-1014] vs. 786 [665-956] HU, p = 0,002). Çok değişkenli analizde, BMI (OR 1,245, %95 CI 1,025–1,512, p = 0,028), taş dansitesi (OR 1,003, %95 CI 1,001–1,004, p = 0,002), renal pelvis idrar dansitesi (OR 1,032, %95 CI 1,009–1,055, p = 0,006) ve taş-cilt mesafesi (OR 1,654, %95 CI 0,986–1,846, p = 0,004) bağımsız öngörücüler olarak kaldı.

Sonuç: VKİ, taş yoğunluğu, renal pelvis idrar dansitesi ve taş-cilt mesafesi parametreleri, proksimal üreter taşı olan hastalarda SWL'yi değerlendirirken faydalı bir rehber olabilir. Bulguları desteklemek için daha geniş örneklemli prospektif çalışmalara ihtiyaç vardır.
Anahtar kelimeler: SWL, ürolitiyazis, acil URS, proksimal üreter taşları

Introduction

Urolithiasis represents one of the leading causes of morbidity in urological practice, and its incidence has been steadily increasing worldwide [1,2]. Currently, miniaturized ureterorenoscopes

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represent the preferred approach for ureteral calculi, given their high efficacy and favorable safety profile [3]. In contrast, for proximal ureteral stones <1 cm, shock wave lithotripsy (SWL) is highlighted by the European Association of Urology (EAU) guidelines as a cost-effective, non-invasive modality associated with fewer stent-related symptoms [4]. Despite these advantages, the clinical success of SWL is far from universal and is influenced by multiple factors, including stone size, density, anatomical considerations, and individual patient characteristics.

Reported stone-free rates for proximal ureteral stones treated with SWL vary considerably, generally ranging between 40% and 80% [5,6]. Treatment failure inevitably leads to the need for secondary interventions, most commonly ureteroscopy (URS). The necessity for an additional procedure not only prolongs treatment but also increases healthcare costs, exposes patients to additional anesthesia and surgical risks, and may negatively affect overall patient satisfaction. Therefore, the ability to identify patients at higher risk of SWL failure is of considerable importance in optimizing treatment planning and minimizing unnecessary procedures.

Previous studies have suggested that stone-related variables, such as diameter and attenuation, as well as host-related factors including hydronephrosis, body mass index (BMI), and sex, may influence SWL outcomes [7,8]. However, evidence specifically focusing on proximal ureteral stones remains limited, and consensus on reliable predictors of SWL failure requiring urgent URS has yet to be established.

The aim of this study is to evaluate the clinical, anatomical, and stone-related factors in patients who underwent SWL for proximal ureteral stones and to identify the risk factors associated with the subsequent need for urgent URS. Identifying such parameters may help refine patient selection, improve individualized treatment strategies, and ultimately enhance both clinical outcomes and patient satisfaction.

Material and Methods

Patient Selection

This study was approved by the Erzurum Medical Faculty Local Ethics Committee (approval number: BAEK 2025/10-265). After ethical approval patients treated with SWL for radio-opaque proximal ureteral stones at the Department of Urology, Erzurum City Hospital included in the study. Patients with incomplete medical records, congenital urinary tract anomalies,

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concomitant renal stones, or stone size greater than 1 cm were excluded from the analysis. Proximal ureter was defined as the segment extending from the ureteropelvic junction to the upper border of the iliac vessels.

Demographic and clinical data were collected, including age, gender, BMI, and comorbidities. Laboratory parameters recorded prior to the procedure were serum creatinine, hemoglobin, white blood cell (WBC) count, platelet count, and urine culture results. Radiological variables obtained from non-contrast computed tomography (NCCT) included stone diameter, Hounsfield unit (HU), renal pelvis urine HU, perirenal stranding, proximal and distal ureteral diameters, stone-skin distance and ureteral wall thickness at the stone level.

After creating the patient sample and collecting related parameters, patients were classified into two separate groups: those who developed an urgent need for URS and those who did not. Urgent URS was applied to patients pain despite medical treatment, fever/sepsis findings, obstruction and increased creatinine, and steinstrasse that refers to the alignment of fragmented calculi within the ureter after SWL.

Disease Management

In accordance with the EAU guidelines, patients with ureteral stones smaller than 1 cm were considered candidates for either SWL or URS. URS was directly indicated in cases of severe renal colic, pyonephrosis, or acute renal failure. In the absence of these factors and in patients without urinary tract infection, SWL was used as the first-line treatment. Each treatment session was performed according to a standardized protocol and consisted of up to 2,000–2,500 shock waves. Shock waves were delivered with a maximum energy setting of approximately 18 kV and a pulse frequency ranging between 1.0 and 1.5 Hz, in accordance with manufacturer specifications (Wolf Piezolith, Germany). Shock waves were targeted under fluoroscopic guidance. Procedures were performed by an experienced registered nurse with more than ten years of training in SWL and were carried out under the supervision of a urology specialist. Analgesia was provided with intravenous paracetamol at a dose of 1 g administered prior to the SWL procedure. Sedation was provided with intravenous midazolam (0.03–0.05 mg/kg) during the SWL procedure. A minimum interval of two weeks was maintained between consecutive SWL sessions.

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Patients were followed at two-week intervals with direct urinary system graphy (DUSG). Additional SWL sessions were administered when necessary, up to a maximum of three. One month after the final session, NCCT was performed to evaluate stone-free status. Urgent URS was performed in cases of severe renal colic or pyonephrosis following SWL. During follow-up, patient-reported outcomes such as pain severity, urinary symptoms, and any adverse events were systematically recorded to assess both clinical efficacy and safety. Laboratory parameters, including serum creatinine and urinalysis, were monitored to detect renal impairment or infection. Patient compliance with hydration and analgesic recommendations was also reinforced, and lifestyle advice was provided to minimize stone recurrence. This structured follow-up ensured timely identification of complications and optimization of individualized management strategies.

Statistical Analysis

All statistical evaluations were performed using IBM SPSS 20.0. Categorical data were summarized as frequencies and percentages. The distribution of continuous variables was examined using the Kolmogorov-Smirnov test. In cases where the data showed normal distribution, comparisons between two groups were carried out with the independent samples t-test, while the Mann–Whitney U test was applied for non-normally distributed variables. Relationships between categorical parameters were assessed using either the Pearson χ^2 test or Fisher's exact test, depending on suitability. A probability value below 0.05 was accepted as the threshold for statistical significance. Univariable and multivariable binary logistic regressions were applied to identify factors associated with the need for urgent URS.

Results

A total of 277 patients who underwent SWL for proximal ureteral stones were included in the analysis. Among the study population, 232 patients (83.8%) did not require urgent URS (Group 1), while urgent intervention was necessary in 45 patients (16.2%) (Group 2) (**Table 1**).

The median age did not differ significantly between none urgent URS group and urgent URS group (44 [33-59] vs. 53 [33-61] years, p = 0.174). Gender distribution was also comparable across groups (p = 0.462). Patients in the urgent URS group demonstrated a significantly higher body mass index (26 [24-27] vs. 25 [24-26] kg/m², p = 0.002). Laboratory parameters, including

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serum creatinine, white blood cell count, hemoglobin, and platelet count, were similar between the two groups ($p > 0.05$ for all) (**Table 1**).

With respect to stone characteristics, the median stone diameter was slightly larger in the URS group (8 [6-10] vs. 7 [4-10] mm, $p = 0.011$). Stone density was also higher among patients requiring URS (862 [784-1014] vs. 786 [665-956] HU, $p = 0.002$). Non-contrast CT findings revealed that renal pelvis urine density and stone–skin distance were markedly greater in the URS group (13 [9-36] vs. 8 [6-11] HU, $p < 0.001$ and 12 [6-16] vs. 9 [7-13] cm, $p < 0.001$, respectively). Furthermore, perirenal stranding was significantly more frequent in the URS cohort (51.1% vs. 25.4%, $p = 0.001$). Other CT-derived parameters, including ureteral wall thickness and ureteral diameters, did not differ significantly (**Table 1**).

Univariable logistic regression identified BMI, stone density, renal pelvis urine density, stone–skin distance, and the presence of perirenal stranding as significant predictors of urgent URS requirement after SWL. In multivariable analysis, BMI (OR 1.245, 95% CI 1.025–1.512, $p = 0.028$), stone density (OR 1.003, 95% CI 1.001–1.004, $p = 0.002$), renal pelvis urine density (OR 1.032, 95% CI 1.009–1.055, $p = 0.006$), and stone–skin distance (OR 1.654, 95% CI 0.986–1.846, $p = 0.004$) remained as independent predictors (**Table 2**).

Receiver operating characteristic (ROC) analysis was performed to further evaluate the discriminative performance of these predictors. The area under the curve (AUC) was 0.640 for BMI (cut-off 24.5 kg/m², sensitivity 66.7%, specificity 46.4; $p = 0.003$) and 0.645 for stone density (cut-off 782 HU, sensitivity 77.0%, specificity 49.1; $p = 0.002$). Renal pelvis urine density demonstrated the highest predictive ability with an AUC of 0.744 (cut-off 9.5 HU, sensitivity 73.5%, specificity 71.2; $p < 0.001$). Stone–skin distance also showed strong predictive capacity (AUC 0.733, cut-off 11.5 cm, sensitivity 71.1%, specificity 70.7; $p < 0.001$). The ROC characteristics are summarized in **Figure 1** and **Table 3**.

Discussion

Endourological approaches remain the most commonly employed treatment modality for proximal ureteral stones; however, the EAU urolithiasis guideline also recommends SWL for stones smaller than 1 cm [3,9]. SWL is often preferred as an alternative option, particularly for patients who decline surgery or present with clinical factors favoring a less invasive intervention.

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Despite its noninvasive nature and associated advantages, SWL can lead to complications such as steinstrasse formation, failure of spontaneous fragment passage, pyonephrosis, renal colic, and renal hematoma [10]. These complications may necessitate additional endourological procedures and, particularly in cases of steinstrasse, may reduce overall treatment success while increasing the need for repeated interventions [11,12]. herefore, identifying risk factors that predict the likelihood of requiring URS in patients with proximal ureteral stones may aid in more accurate patient selection for SWL. Although smaller stone size is associated with higher SWL success and forms the basis of the guideline's 1 cm threshold, it should be recognized that other parameters such as stone density, ureteral caliber, and stone–skin distance may negatively influence SWL outcomes and increase the need for additional procedures and healthcare costs [13,14]. Additionally, the role of patient-specific anatomical and physiological factors in influencing SWL outcomes warrants further consideration. Parameters such as ureteral peristaltic activity, degree of hydronephrosis, and renal pelvic morphology may contribute to variations in stone clearance and the need for urgent interventions, yet these factors have not been systematically evaluated in most studies.

Several studies evaluating risk factors for SWL success have identified parameters such as stone size, ureteral wall thickness, stone density, and stone–skin distance as unfavorable determinants. Muter et al. reported that patients with lower stone density achieved higher stone-free rates [15]. Similarly, Ying Lee et al. identified stone size, density, and skin-to-stone distance as significant predictors of stone-free outcomes [16]. Additionally, various nomograms have demonstrated reliable performance in predicting stone-free status; among these, the Dogan and Onal nomogram which incorporate variables such as age, sex, and stone characteristics have been shown to provide effective predictive value [17,18]. Although our study shares certain features with previous research, it primarily focuses on a less explored clinical domain: the identification of parameters associated with the need for urgent ureteroscopy following SWL. We also evaluated anatomical factors, such as stone-skin distance, proximal and distal ureteral diameters and renal pelvis urine density, which may influence stone fragment passage and the likelihood of urgent intervention. Beyond stone-free rates, determining which patients are at risk for requiring urgent endourological intervention represents another clinically important aspect of SWL treatment. According to our literature review, there is limited data about urgent URS requirement. From a clinical perspective, identifying high-risk patients may help guide consideration of alternative treatments and improve pre-procedural counseling. In addition, studies focusing on the success of

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SWL may lead to the possibility of overlooking the morbidity and costs brought about by the need for urgent URS, and this creates the need for further studies on this subject.

In our retrospective analysis, 16.2% of patients required urgent URS due to renal colic, steinstrasse formation, or pyonephrosis. Across the entire cohort, BMI (OR 1.245, 95% CI 1.025–1.512, p = 0.028), stone density (OR 1.003, 95% CI 1.001–1.004, p = 0.002), renal pelvic urine density (OR 1.032, 95% CI 1.009–1.055, p = 0.006), and stone–skin distance (OR 1.654, 95% CI 0.986–1.446, p = 0.004) emerged as significant predictors of urgent URS. These findings are consistent with previously identified parameters associated with lower SWL success, making their association with urgent intervention unsurprising. Increased BMI and stone–skin distance may reduce the effectiveness of shockwave transmission, potentially contributing to inadequate stone fragmentation. Likewise, stone size continues to influence SWL outcomes, as reported in earlier studies. Notably, renal pelvic urine density derived from NCCT may serve as an early indicator of potential pyonephrosis and appears to be a clinically useful parameter for pre-procedural assessment in SWL candidates. Moreover, integrating these factors into predictive models alongside established variables such as BMI, stone density, and stone–skin distance may improve the accuracy of anticipating which patients are at higher risk for complications or additional procedures.

Our study is not free from limitations due to its retrospective design. The identification of patients who required urgent ureteroscopy based on chart review may have introduced selection bias in determining which patients were classified as needing urgent intervention. Furthermore, the single-center nature of the study, the relatively small sample size, and potential variations related to the center's SWL device, operator experience, and treatment protocols may limit the generalizability of the results. Despite these limitations, the present study represents one of the few investigations in the literature evaluating parameters predictive of urgent endourological intervention following SWL and provides clinically meaningful insights that may guide patient management. Moreover, similar to nomograms developed to predict SWL success, these findings possess characteristics that could serve as a basis for future prospective, randomized controlled studies aimed at identifying factors associated with the need for urgent URS.

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Conclusion

This study identified clinical and radiological parameters that predict the need for urgent ureteroscopy following SWL for proximal ureteral stones. BMI, stone density, renal pelvic urine density, and stone–skin distance were found to be significantly associated with the requirement for urgent intervention. Future prospective, multicenter studies are needed to validate such comprehensive predictive approaches, which could ultimately facilitate more personalized treatment planning, reduce unnecessary interventions, and optimize clinical outcomes in patients undergoing SWL for proximal ureteral stones.

Ethics Committee Approval: This study was approved by the Erzurum Medical Faculty Local Ethics Committee (approval number: BAEK 2025/10-265)
Informed Consent: An informed consent was obtained from all the patients.
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Table 1. Comparison of demographic and clinical characteristics of SWL patients according to urgent URS requirement

Parameter (Median [IQR], n (%))	**Group 1 (n=232)**	**Group 2 (n=45)**	**P value**
Age, (years)	44 [33-59]	53 [33-61]	0.174*
BMI, (kg/m2)	25 [24-26]	26 [24-27]	**0.002***
Gender			0.462#
Male	117 (50.4)	20 (44.4)	
Female	115 (49.6)	25 (55.6)	
Creatinine, (mg/dL)	0.7 [0.6-0.9]	0.7 [0.6-0.9]	0.213*
WBC, ($\times 10^3/\mu L$)	6950 [5640-9280]	6640 [5130-8620]	0.367*
Hemoglobin (g/dl)	13.8 [13.2-14.9]	13.8 [13.4-14.9]	0.622*
Platelet, ($\times 10^3/\mu L$)	298 [247-362]	326 [265-368]	0.102*
Stone diameter,(mm)	7 [4-10]	8 [6-10]	**0.011***
Stone HU	786 [665-956]	862 [784-1014]	**0.002***
Ureter wall thickness,(mm)	2.1 [1.9-2.7]	2.2 [2.0-2.7]	0.454*
Proximal ureteral diameter,(mm)	10 [8-11]	8 [6-11]	0.066*
Distal ureteral diameter,(mm)	6 [5-7]	6 [5-8]	0.852*
Renal pelvis urine HU	8 [6-11]	13 [9-36]	**<0.001***
Stone-skin distance, (cm)	9 [7-13]	12 [6-16]	**<0.001***
Perirenal stranding			**0.001#**
Yes	59 (25.4)	23 (51.1)	
No	173 (74.6)	22 (48.9)	
Number of SWL sessions	2 [1-3]	1 [1-1]	**<0.001***
Time to urgent URS, (days)	-	1 [1-2]	-
Stone free rate	208 (89.6)	37 (91.1)	0.948#

Group 1: SWL none-urgent URS group; Group 2: urgent URS group; HU: Hounsfield unit; BMI: body mass index; *Man-Whitney U test; #Chi-square test

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Table 2. To predict urgent URS requirement after SWL univariable and multivariable logistic regression analysis performed

	Univariable			Multivariable		
Parameter	**OR**	**95% CI**	**P value**	**OR**	**95% CI**	**P value**
Age (years)	1.017	0.995-1.039	0.137			
Gender	1.272	0.669-2.416	0.463			
BMI (kg/m^2)	1.352	1.125-1.625	**0.001**	**1.245**	**1.025-1.512**	**0.028**
Stone diameter (mm)	1.139	0.876-2.284	0.171			
Stone density (HU)	1.003	1.001-1.004	**0.001**	**1.003**	**1.001-1.004**	**0.002**
Proksimal ureter diameter (mm)	0.914	0.816-1.025	0.124			
Distal ureter diameter (mm)	0.977	0.809-1.179	0.807			
Renal pelvis urine density (HU)	1.045	1.025-1.065	**<0.001**	**1.032**	**1.009-1.055**	**0.006**
Ureter wall thickness (mm)	1.295	0.786-2.133	0.310			
Perirenal stranding	3.065	1.592-5.901	**0.001**	1.842	0.874-3.884	0.109
Stone-skin distance	1.372	1.112-1.698	**<0.001**	**1.654**	**0.986-1.846**	**0.004**
Creatinine value (mg/dL)	0.401	0.087-1.859	0.243			
WBC count (µ/L)	1.032	0.858-1.741	0.312			
Hb level (g/dl)	1.054	0.824-1.348	0.677			
Platelet	1.003	0.999-1.007	0.099			

OR: odds ratio; CI: confidence interval; BMI: body mass index; HU: hounsfield unite; WBC: white blood cell; Hb: hemoglobine

Table 3. The predictive capacity of independent risk factors for urgent URS requirement after SWL was examined using ROC analysis.

Variables	Cut-off value	Sensitivity-specificity	AUC	95% CI	P value
BMI (kg/m2)	24.5	(%66.7- %46.4)	.640	.546-.734	0.003
Stone density (HU)	782	(%77.0-%49.1)	.645	.555-.735	0.002
Renal pelvis urine density	9.5	(%73.5-%71.2)	.744	.664-.825	<0.001
Stone-skin distance (cm)	11.5	(%71.1-%70.7)	.733	.651-.816	<0.001

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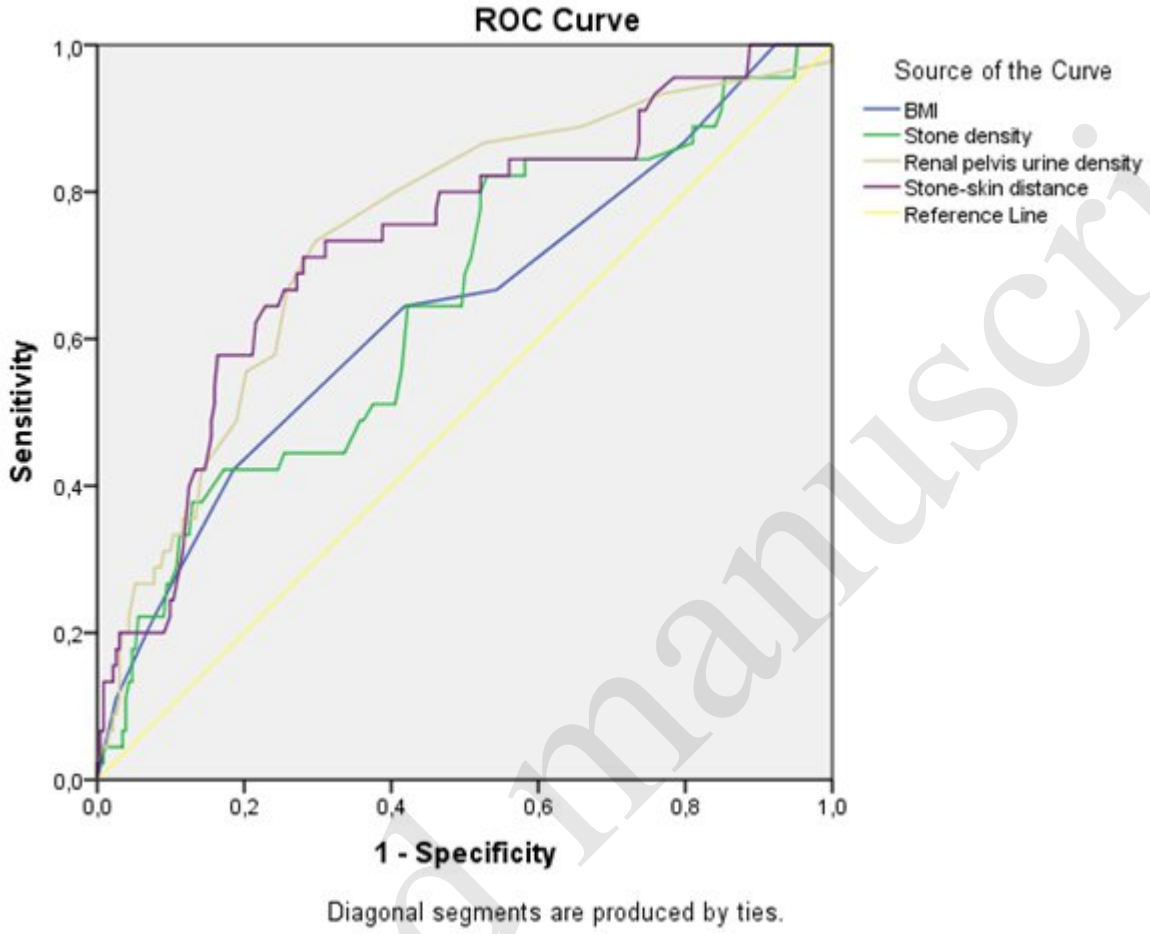

Figure 1. ROC curve of independent risk factors for urgent URS requirement after SWL

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