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# Comparison of Hounsfield Unit and İntraoperative "GATA Scale" Score to Determine Requirement of DJ Stent Insertion in Ureteral Stone Treatment

## Üreter Taşı Tedavisinde DJ Stent Yerleştirme Gerekliliğini Belirlemek İçin Hounsfield Ünitesi ve İntraoperatif "GATA Skala" Puanının Karşılaştırılması

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**What's known on the subject? and What does the study add?**

This work contrary to what is known show that there is a relationship between hounsfield unit and stone size, New scale sets the criteria for DJ stent placement.

## Abstract

**Objective:** In this study, we aimed to determine the contribution of hounsfield unit (HU) measurement with non-contrast-enhanced computed tomography to the treatment of a single ureteral stone, and compare the value of HU and intraoperative "GATA scale" score in deciding for DJ stent placement in patients with a single ureteral stone.
**Materials and Methods:** Ninety patients diagnosed with a single ureteral stone in our clinic between January 2018 and September 2018 were evaluated prospectively. We planned a new scale called "GATA scale" with three benchmarks. The validity and reliability of HU were compared with those of GATA scale score. Statistical significance was defined as $p<0.05$.
**Results:** The mean stone volume at diagnosis was $245.29\pm23.9$ mm$^3$. The mean HU of ureteral stones was $1065.21\pm33.5$. The mean total score according to GATA scale was $6.44\pm0.2$. To determine the threshold value for factors affecting stent placement after lithotripsy, receiver operating characteristic analysis was performed for stone volume, laser duration, total energy to complete laser lithotripsy and GATA scale score and showed that the optimal thresholds were 164.01 mm$^3$, 4.25 mins, 1004 W and 7.5, respectively.
**Conclusion:** In clinical practice, GATA scale can be used in decision making for DJ stents placement. Stent placement following lithotripsy is recommended especially in patients with a stone volume of greater than 160 mm$^3$ or total energy to complete laser lithotripsy over 1000 W or laser duration longer than 4 minutes or GATA scale score higher than 7.
**Keywords:** Ureteral stone, Hounsfield unit, Laser lithotripsy

## Öz

**Amaç:** Bu çalışmada, kontrastsız bilgisayarlı tomografi ile hounsfield ünitesi (HÜ) ölçümünün üreter taşı tedavisine katkısını belirlemeyi ve DJ yerleştirilmesi gereksinimini belirlemek için HÜ ve intraoperatif "GATA skala" puanlarının karşılaştırılmasını amaçladık.
**Gereç ve Yöntem:** Ocak 2018 ve Eylül 2018 tarihleri arasında kliniğimizde tek bir üreter taşı tanısı konan 90 hasta prospektif olarak değerlendirildi. Üç kriter ile "GATA ölçeği" adı verilen yeni bir ölçek planladık. HÜ'nün geçerliliği ve güvenilirliği için GATA skala skoru ile karşılaştırıldı. İstatistiksel anlamlılık $p<0,05$ olarak tanımlandı.
**Bulgular:** Üreteral taşı olan hastalarda tanıda ortalama taş hacmi $245,29\pm23,9$ mm$^3$ idi. Üreter taşlarının ortalama HÜ değeri $1065,21\pm33,5$ idi. GATA ölçeğine göre ortalama toplam puan $6,44\pm0,2$ idi. Litotripsi sonrası stent yerleşimini etkileyen faktörlerin eşik değerlerini belirlemek için taş hacmi,

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lazer süresi, tamamlanan lazer litotripsinin toplam enerjisi ve GATA skala skoru için alıcı işletim karakteristiği analizi yapıldı ve optimal eşik sırasıyla 164,01 mm$^3$, 4,25 dakika, 1004 W ve 7,5 saptandı.
**Sonuç:** Klinik pratikte, GATA skalası, DJ stentlerin yerleştirme kararında kullanılabilir. Özellikle taşın hacmi 160 mm$^3$'ün üzerinde veya toplam enerji 1000 W'nun üzerinde veya lazer süresi 4 dakikadan fazla veya GATA skalası 7'den fazla ise, litotripsiden sonra stent yerleştirilmesi önerilir.
**Anahtar Kelimeler:** Üreteral taş, Hounsfield ünitesi, Lazer litotripsi

## Introduction

Urinary system stones have an important place in urology practice. The prevalence of urolithiasis in economically developed countries has been reported to range between 4% and 20% (1). Large stones may cause obstruction and small ones may produce severe flank or lower abdominal pain. Location of pain varies with the location of the stone. Standard evaluation includes a detailed medical history and physical examination. In the evaluation of acute flank pain, non-contrast-enhanced computed tomography (NCCT), which can determine stone density and plays a role in deciding the modality of treatment is the gold standard (2,3). However, risks associated with radiation due to computed tomography (CT) scanning causes anxiety in everyone. Thus, low-dose and ultra-low-dose protocols are preferred. However, it should be noted that the diagnostic accuracy decreases as the dose decreases (4). Accuracy of hounsfield units (HU) may be queried considering all the above concerns.

In this study, we aimed to determine the contribution of HU measurement to choosing the correct treatment option for a single ureteral stone, and to demonstrate the accuracy or fallibility. Also, we planned to investigate the right alternatives that can be used instead of HU and contribute to clinical practice.

## Materials and Methods

### Patient Population

A total of 90 patients, 77 males and 13 females, who underwent holmium laser lithotripsy (LL) using semirigid ureteroscope for the treatment of single ureteral stone in our clinic between January 2018 and September 2018 were prospectively reviewed.

### Inclusion and Exclusion Criteria

Patients aged 18 years and older having a single ureteral stone were enrolled in the study. Patients, who were found to have missing data during data recording, evaluation or analysis, were excluded from the study. Patients under the age of 18, patients with surgical failure and patients who received combined therapy (LL and pneumatic lithotripsy) were not included in the study.

### Study Design

The study was designed as a prospective study and was conducted according to the principles of the Declaration of Helsinki. No additional test or assessment other than the evaluations performed for the diagnosis of ureteral stone in routine urology practice was done (physical examination, radiography and NCCT).

Age, gender, presence and location of pain, presence of additional disease, history of previous shock-wave lithotripsy or surgery for urolithiasis, smoking habit, stone location, stone volume, opacity of stone, degree of hydronephrosis, presence of ureteral stenosis or ureteral orifice stenosis and presence or absence of ureteral stent placement were recorded.

All patients were evaluated with NCCT preoperatively. Stone protocol NCCT was performed using a 64 detector row helical CT scanner at 120 kV, 240 mA, with 1.25 mm collimation. Stone location was recorded for each patient. Stone location was classified as proximal ureteral, mid ureteral and intramural ureteral. Stone volume was calculated by measuring the three dimensions of the stone in millimeters and then using the formula: length × width × height × $\pi$ × 1/6 (5,6). HU calculations were performed for each stone in 3 different areas on CT images and the mean value was taken.

### Surgical Procedure

Ureteroscopy (URS) with holmium LL (URS-LL) was performed by four urologists (minimum 5 years of experience in the field). We used semirigid ureteroscope 27000 L/K or 27001 L/K (diameter proximal and distal, 7/6.5 and 8/7 Fr, respectively) models of Storz (Germany) and Holmium-YAG laser by the Sphinx 80 Litho (Power Suite 80 W, Katlenburg-Lindau, Germany) for lithotripsy. Excitation/emission wavelengths of the laser fiber were 230/365 µm with an output energy of 0.5/4.5 J and a pulse repetition rate of 4/30 Hz. In URS, the calculi were targeted; dusting was preferred as the main option or the stones were fragmented into pieces as small as possible and stones >4 mm were removed with a basket catheter. Smaller fragments were expected to pass spontaneously. The efficacy of lithotripsy was evaluated by ultrasound and abdominal X-ray one day later.

### A New "GATA" Scale

To compare HU to intraoperative findings; stone hardness, intraoperative laser duration and the total energy to complete

LL were intraoperatively recorded. We designed a questionnaire for the surgeons to fill immediately after each URS. Then, all the patients were divided into three groups according to results for the balanced distribution of the patients in all groups. There were 29, 30 and 31 patients in group 1, 2 and 3, respectively (according to stone hardness, intraoperative laser duration and the total energy to complete LL). Three main subjects were scored from 1 to 3 in the questionnaire. Stone hardness was scored from 1 to 3 (soft, medium-hard and hard). Laser duration that is defined as the time between beginning and end of lithotripsy was calculated and scored from 1 to 3 (0-3.99 min, 4-7.99 min and >8 min). The total energy to complete LL for each stone was calculated by multiplying pulse energy (J) by frequency (Hz) and scored from 1 to 3 (0-999 W, 1000-2499 W and >2500 W). Total score of the scale was between 3 and 9 point. HU and GATA scale score were compared statistically to find the accuracy of HU.

### Statistical Analysis

Statistical analyses were performed using SPSS Statistics 22.0 software (SPSS Inc., Chicago, IL, USA) and Microsoft Excel computer programs. The normality hypothesis was tested using the Kolmogorov-Smirnov test during data analysis. Descriptive statistics for continuous variables were presented as mean and standard deviation. Pearson's correlation coefficient and Spearman's correlation coefficient were used for correlation analyses of the parameters. Also, multinomial logistic regression was evaluated to determine the significance of the risk/effect parameters. Receiver operating characteristic (ROC) curve was applied to determine the cut-off value for significant parameters. Statistical significance was defined as $p<0.05$.

## Results

The mean age of the patients was 45.8±1.52 years (range, 21-75 years). Regarding primary presenting complaints, flank pain was present in 95.55% (86/90). Left flank pain was observed in 51.11% of cases. 24.44% (22/90) of patients had a history of surgical procedure for urinary calculi, and 72.72% (16/22) underwent lithotripsy. 30% (27/90) of patients had a history of shock-wave lithotripsy. Additional disease was found in 28.88% (26/90) of patients. Diabetes Mellitus, hypertension and coronary artery disease were detected in 4, 12 and 4 patients, respectively. 6 of 26 patients had a combination of these diseases. 22.22% (20/90) of patients was smoker or tobacco user.

The location of the stone was proximal ureter, mid ureter and intramural ureter in 37.77% (34/90), 41.11% (37/90) and 21.11 (19/90) of patients, respectively. The mean stone volume at diagnosis in patients with ureteral calculi was 245.29±23.9 $mm^3$. Hydronephrosis was found in 91.11% (82/90) of patients with ureteral calculi and the degree of hydronephrosis was grade 1 in 26.82%, 2 in 39.02%, 3 in 32.92% and grade 4 in 1.21% of patients. The mean HU was 1065.21±33.5 (Table 1). 74.44% (67/90) of patients had opaque, 21.11% (19/90) had semi-opaque and 4.44% (4/90) had non-opaque stones.

The mean GATA scale score was 6.44±0.2. 17.77% (16/90) of patients had soft, 27.77% (25/90) had medium-hard and 54.44% (49/90) had hard stones. The mean laser duration was 8.18±0.89 min. The mean total energy to complete LL was 3258.18±630W (Table 1).

Stent placement after URS-LL was performed in 66.66% (60/90). In 30 patients, stent placement was not required. The GATA scale score was statistically significantly higher in patients who required DJ stent placement ($p<0.0001$). All patients were successfully treated.

There was a statistically significant positive correlation between HU and total GATA scale score. The Spearman's correlation coefficient was 0.49 for this result. There was a statistically significant positive correlation between stone size and HU ($p<0.05$). Also, there was a statistically significant positive correlation between opacity of stones and HU or GATA scale score ($p<0.05$). There was no statistically significant correlation between the size of ureteral stenosis or ureteral orifice stenosis and HU or GATA scale score.

To determine the threshold value for factors affecting stent placement after lithotripsy, ROC analysis performed for stone volume, laser duration, total energy to complete LL and GATA scale score showed that the optimal threshold values were 164.01 $mm^3$ (sensitivity: 60%; specificity: 70%), 4.25 mins (sensitivity: 68%; specificity: 73%) 1004 W (sensitivity: 80%; specificity: 60%) and 7.5 (sensitivity: 45%; specificity: 90%), respectively. ($AUC_{stone\ volume}$=0.70, $AUC_{laser\ duration}$= 0.73, $AUC_{laser\ energy}$= 0.75 and $AUC_{GATA\ scale\ score}$=0.71) (Table 2 and 3) (Figure 1).

## Discussion

Especially in Western countries, urinary stones are one of the most common urological diseases (7). Diagnosis of ureteral stones is rapid using low-dose CT (8). The EAU 2018 urolithiasis

**Table 1. Evaluation of descriptive characteristics in patients with ureteral stone were managed by URS-LL**

| Variable | Mean ± standart deviation (n=90) |
|---|---|
| Age (years) | 45.8±1.52 |
| Volume of stone ($mm^3$) | 245.29±23.9 |
| Hounsfiel unit (HU) | 1065.21±33.5 |
| Laser duration (min) | 8.18±0.89 |
| Laser energy (W) | 3258.18±630 |
| GATA scale score | 6.44±0.2 |

**Table 2. Area under the curve of stone volume, laser duration, laser energy and GATA scale score. Evulation of success in these parameters to predict of stent placement**

| Test result variable (s) | Area | Standard error[a] | Asymptotic sig.[b] | Asymptotic 95% confidence interval | |
|---|---|---|---|---|---|
| | | | | Lower bound | Upper bound |
| Stone volume | 0.707 | 0.057 | 0.001 | 0.595 | 0.819 |
| Laser duration | 0.733 | 0.054 | 0.000 | 0.626 | 0.839 |
| Laser energy | 0.754 | 0.055 | 0.000 | 0.646 | 0.861 |
| GATA scale score | 0.718 | 0.057 | 0.001 | 0.607 | 0.830 |

[a]: Under the non-parametric assumption
[b]: Null hypothesis, true area=0.5

**Table 3. Receiver operating characteristic curve of stone volume, laser duration, laser energy and GATA scale score and sensitivity and specificity ratios of threshold values**

| Variable | Cut-off value | Sensivity | Specificity | LR+ | LR- |
|---|---|---|---|---|---|
| Stone volume | 164.01 mm3 | 60 | 70 | 2 | 0.57 |
| Laser duration | 4.25 mins | 68.3 | 73.3 | 2.55 | 0.44 |
| Laser energy | 1004 W | 80 | 60 | 2 | 0.33 |
| GATA scale score | 7.5 | 45 | 90 | 4.5 | 0.61 |

LR: Likelihood ratio

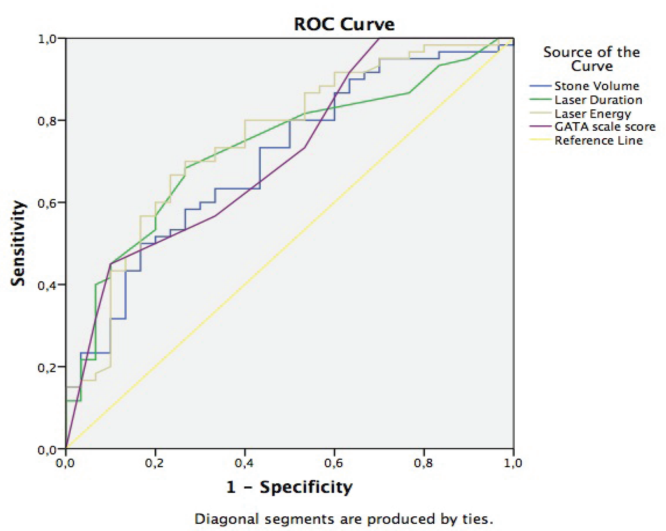


**Figure 1.** Diagonal segments are produced by ties

ROC: Receiver operating characteristic

guideline strongly recommends evaluation of HU on NCCT for ureteral stones (9). HU can be used for diagnosis and selection of the treatment options. However, these methods do not predict the composition of stones with high accuracy.

HU, HU density or $HU_{diff}$ can be used for assessment of ureteral stones (10). These parameters have been evaluated in the literature and their success has been proven in many studies with different results. Baran et al. (11) and Deshmukh and et al. (12) reported that kidneys in patients with calculi have a comparatively high renal cortex and papillae densities than in normal population. However, when the articles were examined in detail, there was no statistically significant difference between some poles of the kidney. These findings support some concerns such as heterogeneity of the measuring area or variability of HU values. In the literature, there are a lot of studies for estimating stone composition with HU values. In some studies, it was reported that HU on NCCT could differentiate just calcium from non-calcium stones (13,14,15). Patel et al. (16) found that HU measurement of urinary stones on NCCT may be used for differentiation of various calcium stone subtypes. However, Stewart et al. (17) reported that for calcium stones, the ability of HU on NCCT to predict stone composition was limited. For brushite stones, HU and HU density can help predict stone composition (18). In another study, Motley et al. (19) reported that neither HU density nor mean HU value was able to identify urinary stones in vivo and to evaluate radiodensities of ureteral stones; HU density was better than HU value. These results show that the HU value changes due to differences in stone composition. However, HU measurements are affected by the heterogeneity of the stone as well as the metabolic structure of the stone. In our study, 49% correlation which was found in our cohort contributes to the debate on the reliability of this method. Deciding by HU value when evaluating treatment options leads to a wrong decision in approximately 50% of cases.

HU can be used in choosing among treatment options (SWL, URS-LL or percutaneous antegrade removal) for ureteral stones. Ouzaid et al. (20) reported that HU was a prognostic factor for success of extracorporeal shockwave lithotripsy (SWL) and 970 HU represented the most sensitive (100%) and specific (81%) point on the ROC curve. Thus, urinary stones with a mean stone density of >1000 HU is deemed to be resistant to SWL (21). El-Assmy et al. (22) found that a stone attenuation of ≤600 HU was a significant independent predictor of SWL success in children. However, HU does not seem to be a predictive parameter for stone expulsion (23). In our cohort, the mean HU value was 1065.21. In our study, there was no correlation between HU value and GATA scale score in patients with a high HU value. Therefore, HU evaluation led us to perform URS-LL in some patients instead of SWL and SWL instead of URS-LL in some patients, which resulted in treatment failure. Also SWL is not a cost-effective treatment option (24). For this reason, a wrong treatment choice leads to a high cost.

In the treatment, rigid or flexible ureterorenoscopes can be used (25). URS-LL has high stone-free rates in all locations of the urinary tract and with all stone types and sizes (26). In URS-LL, fragmentation may be more advantageous than dusting for complete initial stone clearance (27). In our cases, URS-LL was usually performed for fragmentation and the success rate was 100% for ureteral stones. However, dusting method may be preferred especially for stones in the upper urinary tract. However, we did not need it because we routinely used stone cone in our cases.

Routine stenting is not necessary before URS or after uncomplicated URS (complete stone removal). In addition to stone removal, minimal damage to the ureter, such as edema, by using laser energy or URS during operation can lead to severe pain in the postoperative period. Therefore, stone removal is not the only criterion for stenting. However, intraoperative criteria for stent placement are not objective. A scoring based on laser energy, duration of the procedure or intraoperative evaluation has not been done before. Therefore, we think that cutoff values used in our study are extremely important. In addition, ureteral catheters may be routinely used for the first 24 hours after the operation in patients without stent placement. We apply this protocol in our patients. Especially in cases with high energy and long operative time, removal of the ureteral catheter can be waited for up to 48 hours after the operation.

### Study Limitations

The present study has several limitations. This is a single-center study with a small sample size. In our cases, we do not routinely use metabolic evaluation for ureteral stone patients after surgery and accept the fact that not all patients were operated on by a single surgeon experienced in the field of endourology. For these reasons, we believe that larger case series will be more effective in the interpretation of these findings, especially in the evaluation of GATA scale score.

## Conclusion

HU is used for decision of treatment modality in patients with ureteral stones. But we found that HU had a weak correlation with intraoperative GATA scale score. Thus, HU led to false choice in approximately half of the patients. Also GATA scale score can be use in decision making for DJ stent placement. Especially if the volume of the stone is over 160 $mm^3$ or the total energy is over 1000 W or the laser duration is more than 4 minutes or GATA scale score more than 7, stent placement after lithotripsy is recommended.

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### Ethics

**Ethics Committee Approval:** Institutional review board (IRB) approval was acquired from our clinic committee.

**Informed Consent:** Informed consent was obtained from all individual participants included in the study.

**Peer-review:** Externally and internally peer-reviewed.

### Authorship Contributions

Concept: C.E., Ö.Y., Design: C.E., Data Collection or Processing: C.E., Y.E.K., S.A., S.E.Ş., Analysis or Interpretation: C.E., Ö.Y., M.C.T., Literature Search: C.E., H.H.T., Writing: C.E., Ö.Y.

**Conflict of Interest:** No conflict of interest was declared by the authors.

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