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Predictive Value of Preoperative Unenhanced Computed Tomography During Ureteroscopic Lithotripsy: A Single Institute's Experience

Sunchan Kim, Seung-Kwon Choi, Sol Min Lee, Taesoo Choi, Dong-Gi Lee, Gyeong Eun Min, Seung Hyun Jeon, Hyung-Lae Lee, Jun-Young Chung[1], Jin Hyun Joh[2], Koo Han Yoo

Departments of Urology, [1]Anesthesiology and Pain Medicine, and [2]Surgery, Kyung Hee University School of Medicine, Seoul, Korea

Purpose: Ureteroscopic stone removal is frequently used to remove ureteral stones. Mucosal edema and bleeding are the two most important obstacles to a successful operation. This study analyzed relationships between unenhanced computed tomography (UECT) findings and ureteroscopic findings to determine whether ureteroscopic results could be predicted preoperatively by using UECT imaging.

Materials and Methods: From January 2009 to July 2011, 675 patients were diagnosed with ureteral stones through UECT. Among them, we retrospectively reviewed 92 cases of patients who underwent ureteroscopy (URS). We identified findings such as hydronephrosis, rim sign, periureteral fat stranding, and perinephric fat stranding on the UECT and then categorized these findings into four categories (none, mild, moderate, and severe) according to their severity. We also divided the URS findings of mucosal edema and bleeding into four categories (none, mild, moderate, and severe) and compared these findings with the UECT images.

Results: A total of 92 study patients were included in this study: 59 were male and 33 were female patients. According to the location of the stone, 31 cases were classified as upper ureteral stones, 15 were midureteral stones, and 46 were lower ureteral stones. Hydronephrosis identified with UECT was correlated with the mucosal edema severity observed during URS (p=0.004). The rim signs identified with UECT were proportional to the grade of mucosal edema (p=0.010).

Conclusions: Hydronephrosis and rim signs observed during UECT can be used as a predictive factor for intraoperative mucosal edema in patients undergoing URS.

Keywords: *Ureteral calculi; Ureteroscopy; X-ray computed tomography*

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Corresponding Author:
Koo Han Yoo
Department of Urology, Kyung Hee University Hospital at Gangdong, Kyung Hee University School of Medicine, 892 Dongnam-ro, Gangdong-gu, Seoul 134-727, Korea
TEL: +82-2-440-7735
FAX: +82-2-440-7735
E-mail: yookoohan@khu.ac.kr

INTRODUCTION

Unenhanced computed tomography (UECT) is currently being used to diagnose ureteral stones in patients with acute flank pain because this method is rapid, accurate, and safe [1,2]. Factors such as the size and location of ureteral stones are important to determine the course of treatment. Urologists consider these factors in deciding whether to wait for spontaneous passage or to perform extracorporeal shock wave lithotripsy (ESWL) or ureteroscopy (URS).

According to the American Urological Association ureteral stone treatment guidelines, the median stone-free rate for distal ureteral stones less than 1 cm is up to 89% for stones treated by URS [3]. URS can also be useful for situations of uncontrollable pain or when rapid treatment is needed. However, imaging studies performed prior to the operation, such as kidney-ureter-bladder abdominal radiography or UECT, provide little data about the actual surgical findings during URS.

Mucosal edema and bleeding are two of the most common URS complications that can decrease the success of the operation [4]. Although URS is a versatile and frequently used procedure, currently, data about the relationship between preoperative imaging studies and intraoperative URS findings are limited. In the present study, we investigated preoperative UECT analysis as a method for predicting URS outcomes.

MATERIALS AND METHODS

From the total of 657 patients who visited the Urology Department for acute flank pain, who were diagnosed with ureteral stones, and who underwent UECT from January 2009 to July 2011, we retrospectively analyzed 92 cases that were treated with URS. Patients who experienced other treatments such as ESWL or preoperative insertion of a double J stent were excluded from our study.

The UECT images that indicated ureteral stones were confirmed by a radiologist and were then examined for findings such as hydronephrosis or hydroureter, tissue rim signs, periureteral fat stranding, and perinephric fat stranding [5-7]. The hydronephrosis, rim sign, periureteral fat stranding, and perinephric fat stranding identified on the UECT were divided into four categories according to severity (none, mild, moderate, and severe). We classified the degree of hydronephrosis in reference to the grade of vesicoureteral reflux. Cases were defined as absent when hydronephrosis was not indicated by CT, mild when the intrarenal pelvis was prominent or with mild dilatation of the ureter, moderate for intrarenal pelvis or mild ureter dilatation, and severe for marked dilatation of the collecting system.

A positive tissue rim sign was defined as annular soft tissue attenuation (20 to 40 Hounsfield units) caused by an edematous ureteral wall surrounding the stone [8]. This diagnosis was divided into four categories: absent when the rim sign was not present, mild for soft tissue attenuation with a diameter of <2 mm, moderate for a diameter of 2 to 4 mm, and severe when the diameter was >4 mm. Perinephric fat stranding was defined as linear areas of soft tissue attenuation in the perinephric space [9]. Cases without fat stranding were categorized as none; cases with fat stranding were categorized as mild when a few thin strands were visible, severe when many thick strands were visible, and moderate when stranding findings were between mild and severe (Fig. 1).

Ureteroscopic findings were classified at the point of the

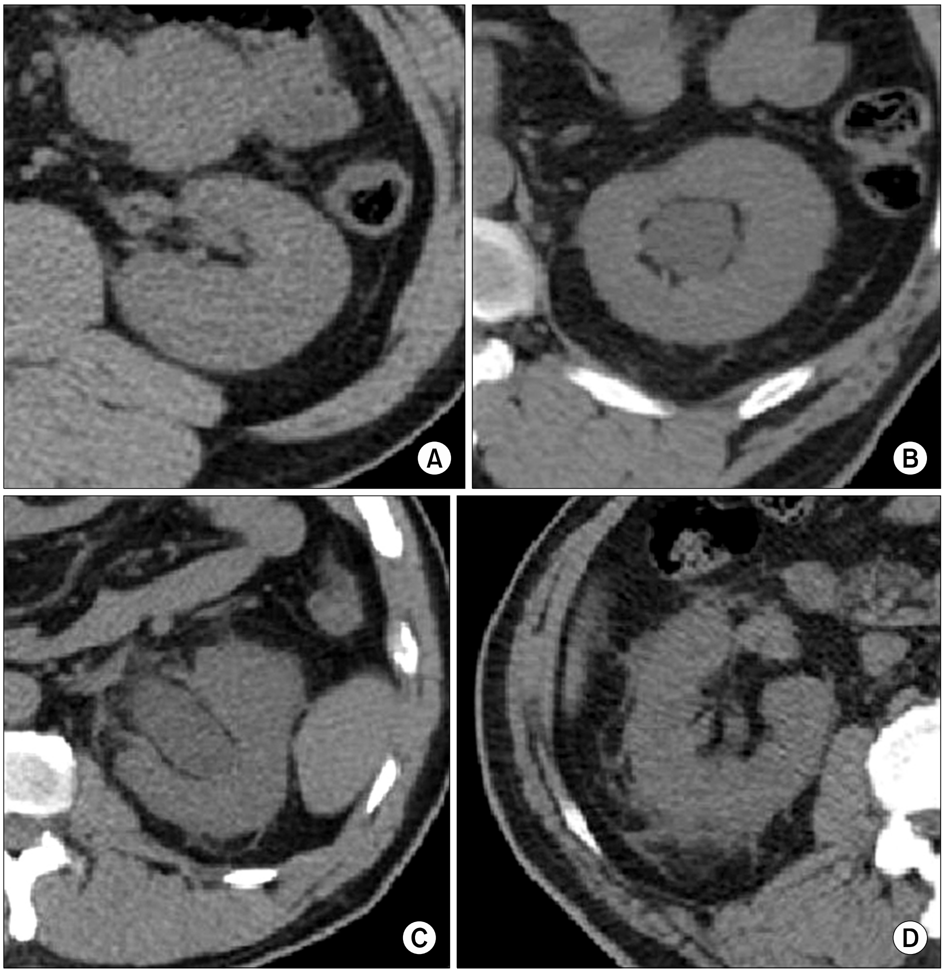

FIG. 1. Images taken from unenhenced computed tomography. Perinephric fat stranding was categorized according to its degree of perinephric fat stranding. A, none; B, mild; C, moderate; D, severe.

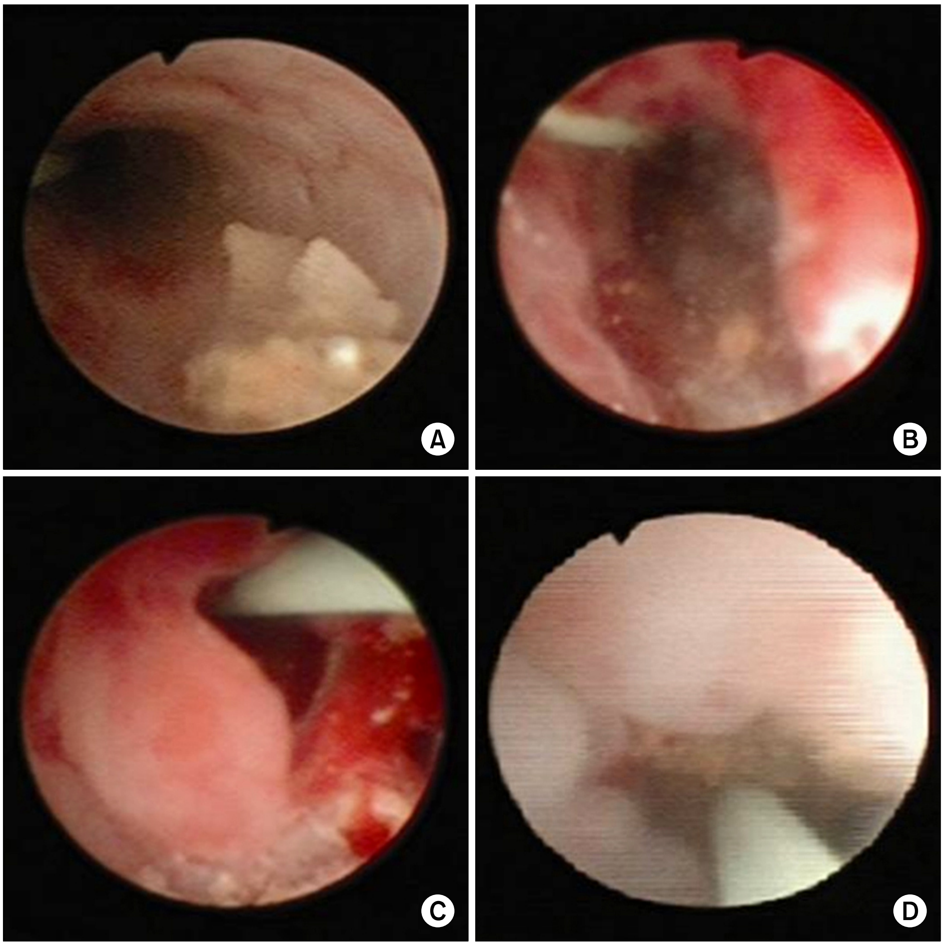

Fig. 2. Images taken during ureteroscopy. Mucosal edema was categorized according to its degree of mucosal edema. A, none; B, mild; C, moderate; D, severe.

mucosal edema and bleeding during URS. The mucosal edema findings were divided into 4 classifications (A, none; B, mild; C, moderate; and D, severe), which are indicated in Fig. 2. Bleeding during URS was divided into 4 groups (A, none; B, mild; C, moderate; and D, severe) by a single urologist and is indicated in Fig. 3.

The data were analyzed to determine whether these ureteroscopic findings (mucosal edema, bleeding) could be predicted with the CT findings described earlier (hydronephrosis, rim sign, periureteral fat stranding, and perinephric fat stranding). Linear-by-linear analysis was used for categorical variables and a value of $p < 0.05$ was considered statistically significant. IBM SPSS ver. 18.0 (IBM Co., Armonk, NY, USA), linear-by-linear, and Fisher exact tests were used.

RESULTS

Of the 92 patients who underwent URS for ureteral stones, 59 were male patients, 33 were female patients, and all had unilateral stones. The cases were categorized according to stone location: 31 were located in the upper ureter, 15 in the middle ureter, and 46 in the lower ureter (Table 1).

Regarding hydronephrosis observed during UECT, 25 patients had none, whereas 39 had mild, 22 had moderate, and 6 had severe hydronephrosis. For mucosal edema observed during URS, 34 patients had no edema, 12 had mild edema, 33 had moderate, and 13 had severe edema. We analyzed the correlation between these two findings and found that the severity of hydronephrosis was proportional to the severity of mucosal edema observed during URS (p=0.004). Regarding the tissue rim sign observed on UECT, 12 patients had none, whereas 22 had mild, 49 had moderate, and 9 had severe findings. The analysis indicated that there was more severe mucosal edema when the tissue rim sign was more severe (p=0.010) (Table 2).

However, this study did not identify a statistically significant relationship between periureteral and perinephric fat stranding and mucosal edema (p=0.577 and p=0.447). In addition, no statistically significant relationship between hydronephrosis, tissue rim sign, periureteral fat stranding, and perinephric fat stranding with intraluminal bleeding was determined in this study (p=0.291, p=0.762, p=0.857, and p=0.703).

There were two ureteral injuries during the operation. However, there were no serious long-term postoperative complications in the 92 patients who underwent URS for ureteral stones at our hospital. Additionally, our hospital had a stone-free rate of 97.8%, which is higher than the average URS stone-free rate, although this could be attrib-

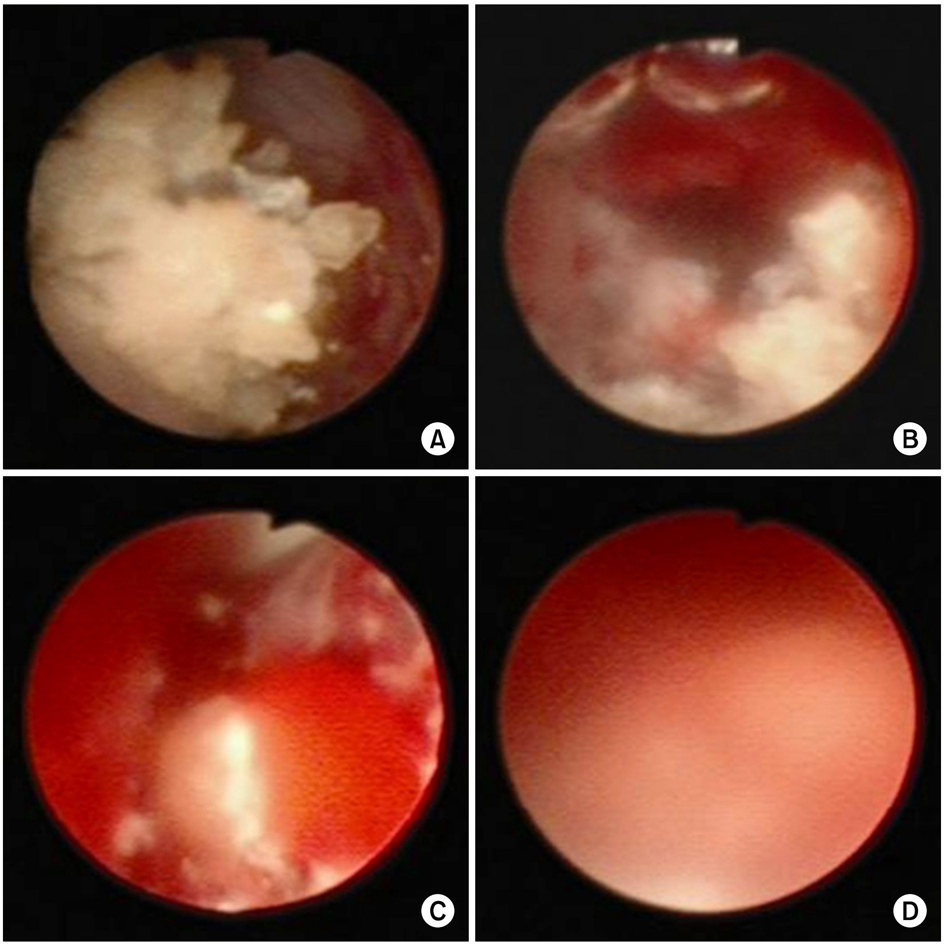

FIG. 3. Images taken during ureteroscopy. Intraluminal bleeding was categorized according to its degree of intraluminal bleeding. A, none; B, mild; C, moderate; D, severe.

utable to the small number of cases included in this study.

DISCUSSION

Ureteral stone management requires consideration of not only imaging findings, such as the stone size and location, but also factors such as symptom severity and duration, patient age and general condition, and the experience of the urologist to determine the timing and modality of treatment [10,11]. ESWL is currently considered to be the least invasive treatment modality for urinary tract stones. In comparison, URS is widely used for ureteral stone treatment because it can be used to directly approach the stone. However, URS is more invasive than ESWL, and ureter damage is a risk of the procedure. With recent advances and the development of a flexible ureteroscope, this method has been associated with greater efficacy for renal stone treatment when compared with other methods such as ESWL and percutaneous nephrolithotomy [12]. Additionally, URS results are associated with better outcomes when the stones are located at the distal ureter [13,14]. The spontaneous passage rate of small distal ureteral stones is approximately 71% to 100%, and conservative management can be considered when symptoms are well controlled. However, if the stone remains in the same location for over 2 months, which occurs with impacted stones, pathologic changes can occur in the ureter, which can cause ureteral stricture or increase the risk of injury during URS [14,15]. These cases also have low ESWL success rates [16]. Therefore, it is important to determine the appropriate time of treatment when patients present with small distal ureteral stones. As shown by the present analysis, URS can be used as an efficient treatment modality in these cases.

Ninety-two URS cases were treated at our hospital, and these included one instance in which stone removal was not possible and one case in which the stone was not discovered. There were two ureteral injuries during the operations. However, there were no serious long-term postoperative complications in the 92 patients who underwent URS for ureteral stones at our hospital.

Because URS is highly successful, the results observed in this study may not have a large impact on clinical stone treatment decisions. This study demonstrated that accurate intraoperative findings can be predicted with specific CT findings, which can contribute to preoperative stone management. Future radiographic image modality development will affect the role of preoperative imaging in stone diagnosis and treatment.

Because this was a retrospective study with a small number of patients, it is possible that there may be a bias in the

Table 1. Baseline characteristics of study patients with ureteral stones (n=92)

Characteristic	Value
Mean age (y)	51.4
Sex (male/female)	59/33
Size of stone (mm)	6.59±3.02
Location of stone (% all URS)	
Upper ureter	31 (34)
Middle ureter	15 (16)
Lower ureter	46 (50)
Hydronephrosis (% all UECT)	
None	25 (27)
Mild	39 (42)
Moderate	22 (24)
Severe	6 (7)
Tissue rim sign (% all UECT)	
None	12 (13)
Mild	22 (24)
Moderate	49 (53)
Severe	9 (10)
Perinephric fat stranding (% all UECT)	
None	48 (52)
Mild	22 (24)
Moderate	7 (8)
Severe	15 (16)
Periureteric fat stranding (% all UECT)	
None	32 (35)
Mild	34 (37)
Moderate	12 (13)
Severe	14 (15)

Values are presented as mean standard deviation or number (%).
URS, ureteroscopy; UECT, unenhanced computed tomography.

Table 2. Relationship between hydronephrosis grade, soft tissue rim sign, and ureteral edema

Variable	Mucosal edema (ureteroscopy)				p-value
	None	Mild	Moderate	Severe	
Hydronephrosis (UECT)					0.004
None	13	2	7	3	
Mild	18	6	11	4	
Moderate	3	2	12	5	
Severe	0	2	3	1	
Rim sign (UECT)					0.010
None	7	1	2	2	
Mild	9	5	7	1	
Moderate	17	6	20	6	
Severe	1	0	4	4	

UECT, unenhanced computed tomography.

results. This study classified mucosal edema and bleeding during URS by ureteroscopic findings. However, pictures were classified during URS, which can be subjective and may therefore have influenced the outcomes of this study.

UECT is an accurate, rapid, and safe examination for patients who present with acute flank pain, and this test can be used to diagnose and treat ureteral stones [17,18]. Our hospital uses CT imaging instead of intravenous pyelogram to diagnose and evaluate acute flank pain. Our hospital has established a system that allows the patient to undergo a CT examination on arrival for rapid diagnosis and treatment.

Smith et al. [8] reported that UECT could be used for patients with ureteral stones, and a study by Ege et al. [9] indicated that secondary signs could be used to evaluate urinary tract obstruction. Numerous studies have analyzed and confirmed that secondary signs identified during CT, such as hydronephrosis, tissue rim sign, and perinephric stranding, can be used to help manage both the treatment and the diagnosis of ureteral stones.

This study attempted to predict intraoperative URS findings by use of indications determined during UECT. The results showed that the severity of hydronephrosis correlates to the degree of ureteral edema, and that periureteral fat stranding can be used to predict the amount of bleeding during the procedure. The other factors were not statistically correlated with mucosal edema or intramural bleeding. Ureteral mucosal edema observed during URS is problematic for advancing the ureteroscope and also for fragmented stone removal. Bleeding inhibits stone visualization and is considered to be a primary factor that can affect the URS success. However, based on our results, these factors can be predicted with UECT prior to treatment. Because operations on patients with these risk factors have an increased risk of failure, urologists must be cautious and aware of the risks and possible outcomes. This study presents a diagnostic technique that may to help reduce and prevent possible URS complications.

Because there were no instances of postoperative complications, this study was unable to examine the relationship between complications and CT findings. Finally, this study did not determine a correlation between CT findings and treatment success. Additional studies are needed to identify correlations between findings and treatment outcomes.

CONCLUSIONS

Hydronephrosis and rim signs observed during UECT can be used to predict intraoperative mucosal edema during URS. In these cases, urologists can use UECT to identify and anticipate intraoperative findings, which can reduce URS complications.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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