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Original article

Outcome of ureteral distensibility on the success of ureteroscopy: A prospective hospital-based descriptive study☆

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Abstract
Introduction: "Difficult ureter" is a known problem that increases the complications during ureteroscopy.
Objective: To categorize ureters according to their distensibility, and to determine whether ureteric distensibility is associated with the success of ureteroscopy and its complications.
Subjects and methods: Between January 2010 and September 2012, we tested ureteral distensibility in 306 patients who had a unilateral single radiopaque ureteral stone, 6–20 mm in diameter. Ureteral distensibility was classified into two categories according to the maximum size of a ureteral dilator that could be introduced before ureteroscopy: non-distensible ureters, which admitted a dilator up to 10 Fr and distensible ureters, which admitted a dilator >10 Fr. Correlations between distensibility and the success rate and complications of ureteroscopy were determined.
Results: Overall, 102 patients (33.3%) had non-distensible ureters and 204 (66.7%) had distensible ureters. Distensibility was correlated with the success of ureteroscopy because initial ureteroscopy failed in 38.2% of non-distensible ureters. Ureteroscopy was successful in all distensible ureters. The incidence of ureteric injury was higher in non-distensible ureters than in distensible ureters.
Conclusions: Our results suggest that ureteric distensibility should be tested before ureteroscopy. Primary ureteroscopy is recommended in distensible ureters because of its low complication rates and favorable outcome. Pre-stenting may be necessary before ureteroscopy in non-distensible ureters; secondary ureteroscopy may be safer and more feasible in these settings.

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Introduction

Ureteroscopy has become the standard of treatment for ureteral stones. The term "difficult ureteroscopy" has recently emerged to describe a situation that affects about 10% of patients undergoing ureteroscopy. In 2011, Cetti et al. recommended pre-stenting in patients with narrow ureters to improve the likelihood of successful ureteroscopy, and to decrease the risk of complications [1].

The technological advances in ureteroscopy have helped to improve the potential to negotiate difficult ureters and more proximal stones with less complications using smaller semi-rigid and flexible scopes [2], yet a lot of centers do not have the luxury of continuously updating their scopes, and they have to deal with their patients using older (though often more robust) technologies [3].

Many urologists try to avoid forced ureteral dilation to allow passage of the ureteroscope [4]. We hypothesize that calibration of the ureter before ureteroscopy may be valuable to define ureteral "distensibility" and avoid complications such as ureteral injury as well as failure to reach the stone. To test our hypothesis, we classified ureters according to their distensibility and determined the associations between ureteric distensibility and the success of ureteroscopy and its complications.

Subjects and methods

This is a prospective hospital-based descriptive study performed between January 2010 and September 2012 in our tertiary referral endourology unit. The study included patients with a unilateral single radiopaque stone of 6–20 mm diameter that was located anywhere in the ureter, except in the intramural part. Children, pregnant females, patients with intramural stones, calcular anuria and patients with stones >20 mm in diameter were excluded from this study.

X-ray imaging of the kidney, ureter, and bladder, urinalysis, ultrasonography, and non-contrast computed tomography were performed in all patients. Patients eligible for ureteroscopy were invited to participate in this study and all procedures were performed electively. The data (patients' age, sex, stone location, stone laterality and stone size) collection was conducted after written consent from the patients, and permission from our institutional ethics committee. The investigation was carried out in accordance with the declaration adopted by the 18th World Medical Association (WMA) General Assembly, Helsinki 1964, and as revised by 64th WMA General Assembly in Fortaleza, Brazil, October 2013.

All procedures were performed under spinal anesthesia by three experienced endourologists. Initially, a Zebra® guide wire (Boston Scientific) was introduced into the ureter bypassing the stone and reaching the renal pelvis. If an impacted stone prevented the passage of the guide wire, the wire was left just below the stone. Sequential Teflon™-coated ureteric dilators (Boston Scientific) were used to calibrate the entire length of the ureter below the stone. The aim of this procedure was to calibrate but not dilate the ureter. According to this calibration, the ureters were classified into two groups: non-distensible ureters that admitted dilators of ≤10 Fr and distensible ureters that admitted dilators >10 Fr.

Ureteroscopic lithotripsy was performed using a semi-rigid Richard Wolf ureteroscope (8.5 Fr tip, reaching 11 Fr at the proximal end) and Swiss Lithoclast pneumatic lithotripter. Stone free status was defined as complete clearance (if stone completely disintegrated and retrieved outside the ureter) and partial clearance (if stone was incompletely disintegrated or retro-pulsed to kidney). Ascending ureterography was performed at the end of the procedure and before ureteral stenting. An open-tip ureteric catheter was routinely kept in place for 3 days. In case of ureteric injury, defined as partial mucosal discontinuity with or without contrast extravasation, a JJ stent was inserted for 1–3 months. Ureteric injury was considered incomplete if ureteric wall injury occurred without dye extravasation during ascending ureterography (which is done routinely at the end of the procedure). If dye extravasation was present, the injury was considered complete.

All patients were evaluated on the first postoperative day by plain X-ray imaging of the kidney, ureter, and bladder to assess the degree of stone clearance and to confirm the position of the stent. Patients with ureteric injury were followed in our inpatient department for 3 days. During hospitalization, abdominal ultrasound was repeated daily to confirm the absence of fluid collection. The presence of fever, hematuria, and bowel symptoms were also assessed. Three months later, patients underwent urinalysis; plain X-ray of the kidney, ureter, and bladder; and abdominal ultrasound to screen for residual stone fragments or hydronephrosis; as well as screened for urinary tract infection.

Data analysis

Statistical analyses were performed using SPSS for Windows version 16 (SPSS Inc., Chicago, IL, USA). A p value <0.05 was considered statistically significant.

Results

Patient disposition

A total of 306 patients were included in our study. Their mean age was 28 years (range 16–57 years). Primary ureteroscopy was performed in 267 patients and secondary ureteroscopy was performed after pre-stenting because of failure to reach the stone in 39 patients.

Associations of ureteral distensibility with patient and stone characteristics

Table 1 shows the degree of ureteric distensibility and its association with patient and stone characteristics. Ureteral calibration assessed before ureteroscopy revealed that 102 (33.3%) patients had non-distensible ureters and 204 (66.7%) had distensible ureters. Ureteral distensibility was significantly associated with stone location ($p = 0.006$); 43.1% of the non-distensible ureters had middle ureteral stones. The patient's sex, stone laterality, and stone size were not associated with the degree of ureteral distensibility.

Associations of ureteral distensibility with ureteroscopy outcome

For patients who had failed ureteroscopy (39 patients with non-distensible ureters), we failed to advance the ureteroscope more than 2–6 cm from the ureteric orifice. For these patients, a ureteric catheter was used as a pre-stent for 5 days in 21 patients and a JJ was used as a pre-stent for 2 weeks before secondary ureteroscopy in 18 patients. The type of pre-stent used depended on when the

Table 1 Degree of ureteric distensibility and its relation to patient and stone characteristics using Chi-squared test.

		Ureteral distensibility		*p* value
		≤10 Fr No. (%)	>10 Fr No. (%)	
Sex	Male	78 (33.5%)	155 (66.5%)	0.924
	Female	24 (32.9%)	49 (67.1%)	
Laterality	Right	49 (30.8%)	110 (69.2%)	0.332
	Left	53 (36.1%)	94 (63.9%)	
Stone location	Distal ureter	40 (31.2%)	88 (68.8%)	0.006
	Middle ureter	44 (44.9%)	54 (55.1%)	
	Proximal ureter	18 (22.5%)	62 (77.5%)	
Stone size	<12 mm	69 (33.5%)	137 (66.5%)	0.931
	>12 mm	33 (33.0%)	67 (67.0%)	

Table 2 Effect of ureteral distensibility on ureteroscopy outcome and ureteral injury using Chi-squared test.

		Ureteral distensibility		*p* value	Correlation coefficient
		≤10 Fr	>10 Fr		
Outcome	Successful ureteroscopy with complete clearance	40 (17.2%)	193 (82.8%)	0.000	.208
	Successful ureteroscopy with partial clearance	23 (67.6%)	11 (32.4%)		
	Failed ureteroscopy	39 (100.0%)	0 (0.0%)		
Injury	No ureteric injury	50 (20%)	200 (80%)	0.000	−.339
	Ureteric injury	14 (77.8%)	4 (22.2%)		

Table 3 Binary logestic regression test for risk of ureteric injury.

Risk factor	Ref. group	Odd ratio	95% C.I.	
			Lower	Upper
Ureteral distensibility	Distensible ureter	**11.334**	5.665	74.695
Site (middle ureter)	Lower ureter	10.420	1.942	55.904
Site (upper ureter)		10.654	1.747	64.968
Stone size	<12 mm	2.745	.833	9.043
Sex	Male	1.303	.389	4.362
Laterality	Right	.320	.096	1.072

patient could be returned to the operative schedule. All patients who required secondary ureteroscopy were successfully treated and the stones were completely cleared without causing ureteric injury.

Among patients who underwent primary ureteroscopy, the stone was completely cleared in 233 patients (87.3%). In the remaining 34 patients partial clearance occurred (12.7%); among those, 26 patients underwent secondary ureteroscopy between 5 days and 2 weeks later, depending on the presence or absence of ureteric injury and the stones were successfully cleared. Eight patients with retropulsion were treated with shock wave lithotripsy after insertion of a ureteric stent.

Ureteric injury was found intra-operatively by ureteroscopy and fluoroscopy in 18 patients (6.7%). Ureteric injury was located in the mid ureter in 10, upper ureter in 6 and lower ureter in 2 patients. Ureteric injury was incomplete in 17 patients and occurred during stone disintegration (due to inevitable stone friction against the tight ureteric wall during hard stone disintegration) or extraction of the stone fragments (during extraction of multiple fragments at same time). Those patients were managed by inserting a JJ stent for 1 month if stone clearance was complete or for 2 weeks before secondary ureteroscopy if stone disintegration was incomplete. Only one male patient experienced complete ureteric injury during stone disintegration. He had a 15 mm impacted stone in the middle third of a non-distensible right ureter. He underwent open surgery because a JJ stent could not be inserted endoscopically.

Ureteric injury during ureteroscopy was significantly associated with non-distensible ureters (Table 2), and with higher stone location (Table 3). The outcome of ureteroscopy was significantly associated with ureteric distensibility where primary ureteroscopy was unsuccessful in 100% of the non-distensible ureters. There were no unsuccessful procedures in the distensible ureters (Table 2). All 17 patients with incomplete ureteric injury returned for a follow-up visit 3 months after the last endoscopic procedure; none had evidence of ureteral stricture. In the patient with complete ureteric injury, ultrasound and intravenous pyelography revealed evidence of ureteral narrowing, which was successfully treated by balloon dilation. Regarding the other patients, only 95 patients (37%) attended the follow-up visit, which is the usual rate at our center [3].

Discussion

In this report, we used ureteric distensibility to describe the ureteric response to ureteric calibration assessed using serial dilators. From

the efficiency of practice standpoint, if a protocol in potential ureteroscopy for stone is to go to operative room for possible ureteroscopy, pass a guide wire, calibrate the ureter. If we are unable to pass a 10 Fr dilator, a stent is placed and secondary ureteroscopy is the pathway. The saving is that no additional time, nor reprocessing of the ureteroscope is needed if the patient fails the calibration test. However, some degree of ureteric dilatation is usually obtained as a secondary response to this calibration procedure. Although being subjective and difficult to define, the difference between dilation and calibration (how much force is used) is likely well appreciated by experienced endourologists. Active ureteral dilation is becoming less common because it does not prevent complications nor does it improve the outcomes of ureteroscopic lithotripsy [5–7]. We think that non-intentional active ureteral dilation occurs during ureteroscopy either following the introduction of the ureteroscope itself or through hydro-dilation. However, the question remains: will all ureters respond to non-intentional dilatation?

In the present study, we found two levels of ureteric response during calibration, which are caused by the degree of ureteric distensibility. The first type was non-distensible ureters, which would not allow dilation past 10 Fr absent resistance. About 33% of the patients in our study had non-distensible ureters. Ureteroscopy failed in 39 patients for whom their ureters were passively dilated using a ureteric stent for 5–15 days before performing secondary ureteroscopy. Secondary ureteroscopy in these patients did not require dilation and was associated with successful stone clearance with minimal complications. In the recent years, ureteral stenting before ureteroscopy to induce ureteric relaxation (i.e., passive dilatation) has received much attention in the literature. Pre-stented patients had fewer minor and major complications than patients who did not receive a stent before stone treatment. Ureteric perforations were more frequent in the non-stented patients [1,4,8–11]. Rubenstein et al. reported that the stone-free rate was greater in patients with pre-stenting than in those without pre-stenting (67% vs. 47%) [10].

However, difficult or non-distensible ureters are not clearly defined in the literature. Several complications, including ureteric injury and perforation, may occur in patients with very narrow ureters [12–15]. Cetti et al. reported that 8% of patients undergoing ureteroscopy had a difficult ureter [1]. We hypothesized that very narrow ureters may be caused by ureteric hypoplasia, ureteric muscle spasm, or low urine flow because of the presence of an impacted or non-impacted stone. We believe that patients with a very narrow ureter (if resistance is met) should be identified before ureteroscopy because acute dilation and vigorous ureteroscopy may cause serious ureteric injury and ureteral injury related to stone disintegration or stone fragment extraction could be avoided. Also identifying those cases through calibration could limit time in the operative room attempting to pass the ureteroscope and instrument reprocessing.

The second type was distensible ureters, which could admit dilators >10 Fr. This type was found in 66.7% of our patients. This group of patients had a higher stone-free rate (82.8%) relative to the other group. In addition, less ureteric trauma was seen (only 4 patients experienced ureteric injury). Stone manipulation was relatively easy in distensible ureters because they could withstand stretching of the ureteric wall during stone manipulation.

In this study, we used a semi-rigid 8.5 Fr ureteroscope. Smaller format and flexible ureteroscopes are more fragile as well as more expensive; a challenge for those centers that are more resource limited. For stone disintegration, we only performed pneumatic lithotripsy. A major limitation of this procedure is the possibility of retrograde expulsion of stone fragments. However, this pneumatic lithotripsy is cost-effective and its complication rate is similar to that of holmium laser therapy, especially for distal ureteric stones [3]. However, holmium laser therapy is expensive and is not available in many centers. Nevertheless, it is appropriate for stones with a high risk of upward migration, particularly stones located in the proximal ureter. Thus, most studies recommend holmium laser therapy for proximal ureteric stones to avoid upward migration and ureteral perforation [16–18].

Another limitation to our study is the use of 8.5 Fr ureteroscope while smaller scopes are available. However, this was the ureteroscope that is available in our institution and it is still used in many centers especially those on low budget.

Finally, the new scopes especially the flexible may not be suitable for every center due to financial issues, especially in developing countries. The findings and conclusions may be different in case of a non-distensible ureter if flexible ureteroscope is used for stone treatment. Therefore, we recommend repeating the present study using flexible ureteroscopes and holmium laser disintegration to confirm the effect of ureteric distensibility when such armamentarium is employed.

Conclusions

We recommend performing ureteric calibration to test ureteric distensibility before ureteroscopy. Because of the low complication rate and favorable outcomes with distensible ureters, we recommend that primary ureteroscopy be performed in such patients. Non-distensible or difficult ureters (if resistance is met) should be pre-stented before ureteroscopy and secondary ureteroscopy may be safer and more feasible in such patients thereby no additional time, nor reprocessing of the ureteroscope is needed.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

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

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None.

Conflict of interest

The authors declare that they have no conflict of interest.

Authors' contributions

Diaa A. Hameed: Formulating the idea of the research, operating on the patients, analysis of data, scientific writing, and publishing the paper

Ahmed S. Safwat: Helped with scientific writing, and publishing the paper

Mahmoud M. Osman: Helped with scientific writing

Mohamed M. Gadelmoula: Diagnosing the patients, operating, follow up and data collection

Adel Kurkar: Diagnosing the patients, operating, follow up and data collection

Mohamed A. Elgammal: Developed the research idea, operated the patients, followed them up, data analysis

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