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ORIGINAL ARTICLE

A treatment strategy to help select patients who may not need secondary intervention to remove symptomatic ureteral stones after previous stenting

Elena Stojkova Gafner[1] · Thomas Grüter[1] · Marc A. Furrer[1] · Piet Bosshard[1] · Bernhard Kiss[1] · Mihai D. Vartolomei[2] · Beat Roth[1,3]

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Abstract

Purpose This study aimed at evaluating whether removal of the ureteral stent the day before scheduled secondary intervention facilitates spontaneous ureteral stone passage and thus can spare the pre-stented patient this surgery.

Methods Retrospective analysis of a single-centre consecutive series of 216 patients after previous stenting due to a symptomatic ureteral stone from 01/2013 to 01/2018. Indwelling stents were removed under local anaesthesia. Patients were told to filter their urine overnight. Multivariate analysis was performed to assess predictive factors for spontaneous stone passage.

Results 34% (74/216) of patients had spontaneous stone passage while the stent was indwelling. Of the remaining 142 patients, 41% (58/142) had spontaneous stone passage within 24 h after stent removal. Only 84/216 (39%) patients needed secondary intervention. Multivariate logistic regression analysis of all 216 patients showed a significant association between spontaneous stone passage and smaller stone size ($p < 0.001$), distal stone location ($p = 0.046$) and stent dwell time ($p = 0.02$). Predictive factors for spontaneous stone passage after stent removal were smaller size ($p < 0.001$), distal location ($p = 0.001$), and stone movement while the stent was indwelling ($p = 0.016$). A treatment strategy was established that helps select patients suitable for conservative management.

Conclusions The majority (61%) of ureteral stones passed spontaneously after pre-stenting; 34% while the stent was indwelling, 27% within 24 h after stent removal. Besides distal stone location, stone size (< 6 mm) and stone movement (≥ 5 cm) while the stent is indwelling indicate patients who are likely to pass their ureteral stone spontaneously after stent removal. The treatment strategy (decision tree) presented here helps identify those patients.

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Keywords Double J · Pre-stenting · Spontaneous stone passage · Ureteral stone · Urolithiasis

Introduction

Kidney stone disease is highly prevalent in Western societies and has steadily increased across all demographic groups in recent decades [1]. While most patients with kidney stones are asymptomatic for years or even lifelong, others suffer from (recurrent) symptomatic stone episodes [2]. Fortunately, the majority of urinary stones pass spontaneously [3]. For those that are symptomatic, ureterorenoscopy (URS) has become one of the most popular treatment options over the past 20 years [4] and is now considered a first-line therapy for most ureteral stones [5]. While placement of a preoperative double J stent increases stone-free rates and decreases complications in patients with renal stones, pre-stenting is usually not necessary before URS in patients with ureteral stones [5–7]. However, in some clinical situations (e.g., obstructed kidney with urinary tract infection/sepsis, stone-induced anuria in a single kidney) urgent decompression with a double J stent is often necessary before definitive stone treatment can be performed. Other reasons for

✉ Beat Roth
beat.roth@chuv.ch

1 Department of Urology, University Hospital of Bern, University of Bern, 3010 Bern, Switzerland

2 Department of Cell and Molecular Biology, University of Medicine and Pharmacy, Targu-Mures, Romania

3 Department of Urology, University Hospital of Lausanne (CHUV), University of Lausanne, Lausanne, Switzerland

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pre-stenting are symptomatic and (ureter) obstructing stone fragments after (incomplete) shock wave lithotripsy, unsuccessful/failed primary URS (e.g., due to an unfavourable anatomy), or just the habits of different treating institutions [7].

While a ureteral stent passively dilates the ureter [8], it also diminishes peristalsis and presumably leads to impaired stone passage [9]. Still, spontaneous stone passage is not uncommon after ureteric stent insertion [10]. The question arises, therefore, whether secondary intervention is necessary at all as potential complications might thus be avoided. We thus evaluated whether our institutional policy of removing the ureteral stent the day prior to scheduled secondary intervention can spare the pre-stented patient this additional surgery. Additionally, we tried to distinguish between those patients who are optimal candidates for conservative management (double J stent removal) and those who should undergo secondary intervention without prior stent removal.

Table 1 Patient and stone characteristics

Variable	Value
Gender, *n* (%)	
Female	59 (27)
Male	157 (73)
Age, years, median (range)	54 (18–88)
Stone location, *n* (%)	
Proximal ureter	56 (26)
Mid-ureter	55 (25)
Distal ureter	105 (49)
Stone size, mm, median (range)	5 (2–11)
Stone density, HU, median (range)	710 (280–1500)
Stone composition, *n* (%)	
Calcium oxalate	102 (47)
Mixed stone composition with ≥ 50% calcium oxalate	13 (6)
Other	7 (3)
No stone analysis available	94 (44)
Stent dwell time; median, range	4 (1–14)

HU hounsfield units

Patients and methods

Study population

We retrospectively analyed a consecutive series of 216 patients [females: 59 (27%); males: 157 (73%); median age 54 years (range 18–88)] who were scheduled for secondary intervention after prior double J stenting due to a symptomatic, radiopaque ureteral stone at our institution from January 2013 to January 2018 (Table 1). The reason for double J stenting was obstructing pyelonephritis/urosepticemia in 69/216 (32%) patients, drug-resistant pain and non-availability of URS equipment in 57/216 (26%), unsuccessful primary URS due to insufficient visibility in patients under anticoagulation therapy in 18/216 (8%), and unfavorable anatomy in 72/216 (33%). Patients with percutaneous nephrostomy drainage in situ, previous primary shockwave lithotripsy (SWL) with additional double J stenting and/or additional relevant stone burden that would require active treatment independent of the symptomatic ureteral stone were not included in this study.

Intervention

Double J stents (6Fr/24–28 cm; Kuartz® K-GUARDIAN; PURE Medical Device SA, Geneva, Switzerland) were placed under general/spinal anesthesia. Baseline diagnostics was performed using non-contrast-enhanced computed tomography (NECT) scan in all patients. Stone size was measured in three dimensions on axial and coronal images. Stone density was measured using bone windows on the magnified axial NECT of the stone at maximal diameter. Before and/or during double J stent placement, conventional X-ray scan was used to evaluate whether the stone was radiopaque. If the stone was radiolucent [5] and other factors for a uric acid stone were present [low urinary pH (≤ 5.5), low density on NECT scan (< 350 Hounsfield Units (HU))] [11, 12], oral chemolysis [13] was performed and the patient was not included in the study.

Patients were told to strictly filter their urine and were followed 1–2 weeks after discharge from hospital in our outpatient clinic when secondary intervention was scheduled. No medical expulsive medication (α-blockers) was routinely given after stent placement.

Double J removal and further assessment

If no spontaneous stone passage was noticed while the double J stent was still in place, radiological assessment [X-ray ($n = 172$) and/or low-dose NECT ($n = 12$)] was performed the day prior to scheduled secondary intervention. Immediately thereafter, the double J stent was removed from all patients under local anesthesia using flexible cystoscopes in our outpatient clinic. A single shot of oral antibiotic prophylaxis (amoxicillin/clavulanate, ciprofloxacin or co-trimoxazole; no intravenous fluids) was given at the time of stent removal. If spontaneous stone passage had occurred, patients were discharged and followed up after 2 to 4 weeks by renal ultrasound for any residual hydronephrosis. In case of stone persistence, patients were hospitalized overnight and told to filter their urine. No additional medication (e.g., α-blockers, NSAID) was given on a routine basis. Pain-induced additional use of analgesics (NSAID and metamizole as first choice; pethidine as second choice) and any other adverse events [e.g. urinary tract infection (UTI), renal colic] were recorded. Spontaneous stone passage or persistence of the stone was documented either by presenting the filtered stone and/or radiologically [X-ray ($n = 90$) and/or low-dose NECT ($n = 37$)] the following day. Secondary intervention was only performed in case of persistence of the stone (Fig. 1).

Outcome measures and statistical analysis

The primary endpoint was ureteral stone-free rate at the time of and 24 h after double J stent removal. The secondary endpoint was to assess predictors of spontaneous stone passage. Categorical variables were analyed using Pearson's Chi-square test, while differences in means of continuous variables were analyzed using Student's *t* test. Logistic regression analysis was performed to assess predictive factors for stone passage [stone size (longest diameter; continuously), location (proximal, mid- or distal ureter), density (continuously), stent dwell time (continuously), stone movement while stent indwelling (continuously), reason for initial double J placement, patient's age and gender). To assess stone movement, we measured the (distal) dislocation of the stone from the initial spot immediately after double J placement and compared it to the X-ray pictures before stent removal. Because natural breathing movements of the patient can make evaluation of the exact stone location rather difficult, only stone movement of ≥ 5 cm was counted as stone movement. No stone analysis was available in 94/216 (44%) patients. This is why we included stone density on CT scan as a surrogate parameter in our analysis, a value that is well known before therapeutic decisions are made. Statistical analyses were

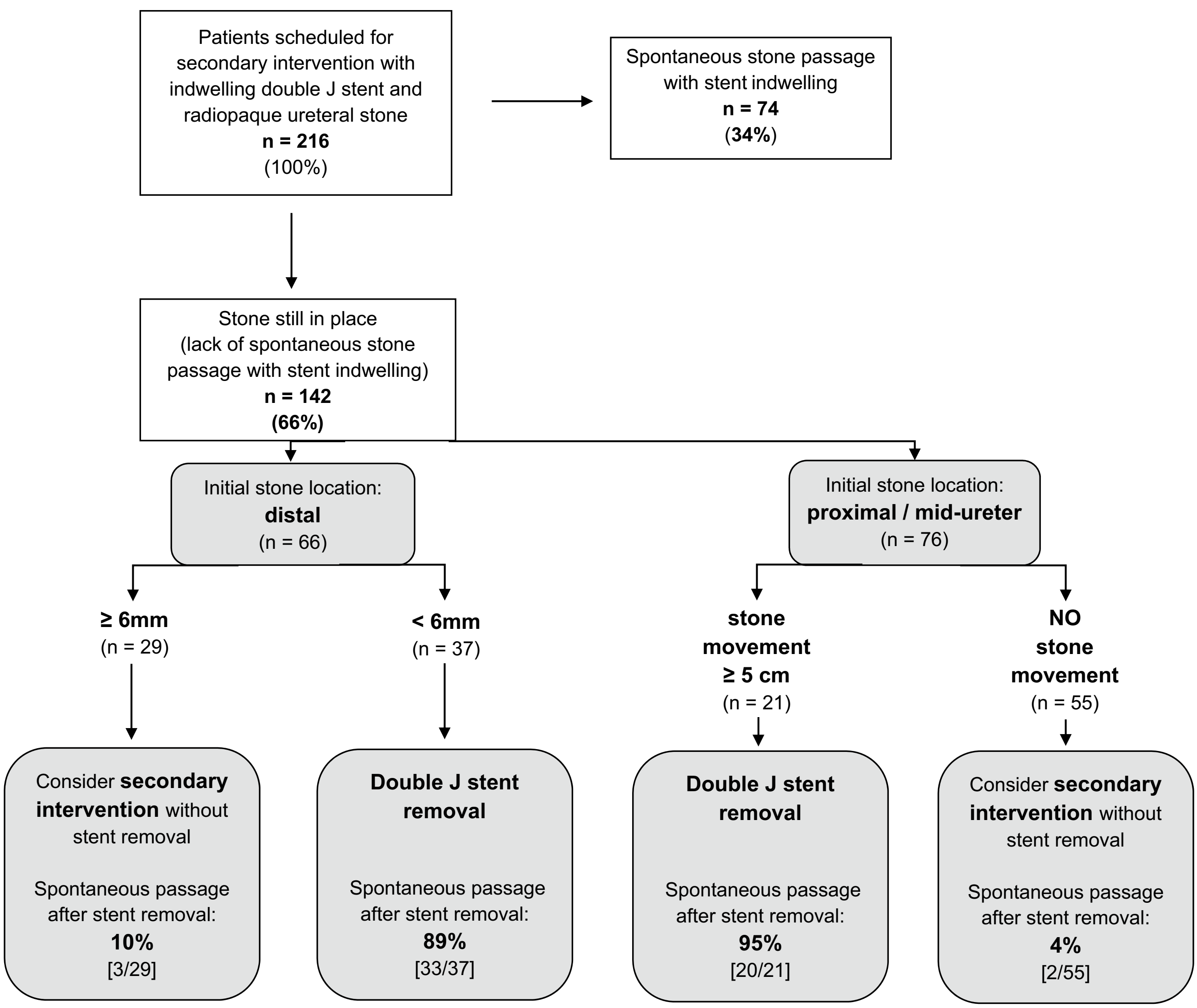

Fig. 1 Treatment strategy (decision tree) for patients after double J stent placement due to symptomatic ureteral stones

performed using Stata 11.0 (College Station, TX, USA). A two-sided p value < 0.05 was considered statistically significant.

Results

During a median stent dwell time of 4 weeks (range 1–14), 34% (74/216) of patients had documented spontaneous stone passage (Fig. 1). Of the remaining 142 patients with the stone still in place in the upper urinary tract, 41% (58/142) had spontaneous stone passage within 24 h after stent removal. No infectious complications occurred after double J stent removal. 28/142 (20%) patients with the stone still in the upper urinary tract required p.o. pain medication (NSAID and/or metamizole) after stent removal (88% of these patients had no spontaneous stone passage); 12/142 (8%) patients experienced renal colic and required pethidine (meperidine; 100% of these patients had no spontaneous stone passage). All in all, only 84/216 (39%) patients needed secondary intervention (URS: $n = 70$; SWL: $n = 14$).

Multivariate logistic regression analysis of all 216 patients showed a significant association between spontaneous stone passage and smaller stone size, distal stone location, and stent dwell time (Table 2). As such, smaller stones (≤ 5 mm) in the distal ureter had the highest rate of spontaneous passage at 95% (73/77). Stone density was significantly associated with spontaneous stone passage in univariate analysis; it did, however, not remain an independent factor for stone passage in multivariate analysis (correlation of stone density and size: $p < 0.001$).

In order to identify patients suitable for conservative management (double J stent removal without immediate secondary intervention) we performed a logistic regression analysis of the 142 patients who did not have spontaneous stone passage while the double J stent was indwelling. Multivariate analysis revealed smaller stone size, distal stone location, and stone movement to be predictive factors for spontaneous stone passage after double J stent removal (Table 3). Using these predictive factors together, we established a treatment strategy (decision tree) that helps select patients with radiopaque ureteral stone after previous stenting who are suitable for conservative management (stent removal without immediate secondary intervention; Fig. 1).

Discussion

To our knowledge, this is the first study to show a relevant benefit from stent removal prior to scheduled secondary intervention for a symptomatic ureteral stone. While one-third of our 216 patients passed the ureteral stone spontaneously with the stent still indwelling, another 27% of patients passed it after stent removal; thus, only 39% of patients needed secondary intervention under general or spinal anaesthesia at all, while 61% of patients did not. Stone location, stone size, and stone movement while the stent is indwelling may be used to select suitable patients for conservative management.

Importantly, ureteral stone passage highly depends on the size and location of the stone, with smaller stones (≤ 5 mm) located in the distal ureter having a > 90% chance of passing spontaneously. The question arises, however, whether

Table 2 Logistic regression to assess predictive factors for spontaneous stone passage in all 216 patients with ureteral stone and indwelling double J stent

Variable	Univariate			Multivariate		
	OR	CI	*p* value	OR	CI	*p* value
Gender	0.68	0.36–1.28	0.2	0.62	0.31–1.26	0.2
Age	1	0.98–1.02	0.6	1.01	0.99–1.03	0.3
Reason for double J placement						
Infectious	Ref			Ref		
URS equipment not available/insufficient visibility	0.87	0.48–1.58	0.7	1.02	0.52–2.02	0.5
Unfavourable anatomy	0.76	0.27–2.16	0.6	0.79	0.24–2.57	0.3
Location						
Proximal ureter	Ref			Ref		
Mid-ureter	0.96	0.45–2.02	0.9	1.19	0.51–2.78	0.6
Distal ureter	2.38	1.22–4.66	**0.011**	2.12	1.01–4.60	**0.046**
Stone size	0.65	0.55–0.78	< **0.001**	0.67	0.54–0.83	< **0.001**
Stone density	0.99	0.997–0.999	< **0.01**	0.99	0.99–1	0.1
Stent dwell time	1.1	0.97–1.25	0.1	1.2	1.03–1.4	**0.02**

Bold indicates the results with statistical significance

OR Odds ratio, *CI* confidence interval, *Ref* reference (proximal ureter), *URS* ureteroscopy

Table 3 Logistic regression to assess predictive factors for spontaneous stone passage after double J stent removal in 142 patients without spontaneous stone passage while double J stent indwelling

Variable	Univariate			Multivariate		
	OR	CI	*p* value	OR	CI	*p* value
Gender	1.82	0.60–5.56	0.3	0.45	0.16–1.22	0.2
Age	1.01	0.97–1.05	0.6	0.99	0.97–1.03	0.8
Reason for double J placement						
Infectious	Ref			Ref		
URS equipment not available/insufficient visibility	1.7	0.82–3.57	0.2	2.18	0.85–5.59	0.1
Unfavourable anatomy	2.66	0.63–11.25	0.2	3.77	0.60–23.82	0.2
Location	2.3	0.78–6.77	0.1	7.77	2.27–26.60	**0.001**
Stone size	0.6	0.40–0.91	**0.007**	0.45	0.21–0.51	**< 0.001**
Stone density	1	0.998–1.002	0.7	1	0.99–1.01	0.7
Stent dwell time	1.01	0.75–1.35	0.1	1.05	0.84–1.32	0.7
Stone movement[a]	2.48	1.62–3.81	**< 0.001**	6.03	1.40–25.89	**0.016**

Bold indicates the results with statistical significance

OR Odds ratio, *CI* confidence interval, *Ref* reference (proximal ureter), *URS* ureteroscopy

[a]Stone movement while stent indwelling

pre-stented patients with larger ureteral stones should be offered stent removal prior to secondary intervention as the chance of spontaneous stone passage decreases rapidly with larger stone diameter (only 38% for stones ≥ 6 mm) and operating room time slots have to be reserved in advance (at not irrelevant cost). We thus analyzed our group of 142 patients without spontaneous stone passage with the stent indwelling and found stone size, stone location, and stone movement to be predictive factors. These data allowed us to develop a treatment strategy that helps predict spontaneous stone passage in most patients (Fig. 1). Accordingly, every pre-stented patient with a ureteral stone in situ can be counselled individually. Optimal candidates for conservative management should then be offered stent removal prior to scheduled secondary stone intervention. This selection process is even more important as patients without spontaneous stone passage after stent removal might develop relevant pain or renal colic (8% of patients after stent removal) and thus are difficult to treat in an in outpatient setting, while those patients identified according to our algorithm do not need overnight stay.

Insertion of a double J stent has been shown to cause a decrease in or even arrest of ureteral peristalsis [14, 15] leading to impaired stone passage [10, 15]. However, spontaneous stone passage with the stent in place is not uncommon [16] and was seen in 34% of all our patients. These at first sight contradictory results are at least partially explained by the generally smaller stone size as compared to the study of, e.g., Baumgarten et al. [10]. Furthermore, α-blockers have been shown to induce ureteric relaxation (predominantly of the distal ureter) in vitro; still, they are used as medical expulsive therapy [17, 18]. Thus (and in contrast to the results of Baumgarten et al. and Ryan et al. [10, 15]), reducing (at least distally) ureteric muscle tone seems to have a beneficial effect on stone passage [19].

Although most patients with symptomatic ureteral stones do not require pre-stenting, it is unavoidable in some clinical situations or if unfavourable anatomy does not allow primary ureteroscopic treatment. Side effects of indwelling stents, however, are common with stent-related symptoms in up to 80% of patients and a higher rate of complications (e.g., urinary tract infections) compared to non-stented patients following URS [20–23]. Therefore, stent dwell time should be limited until the clinical situation (e.g., full recovery from urosepticemia) allows secondary intervention. All the more so since we could show that spontaneous stone passage after stent removal occurred independently of the previous stent dwell time. Still, the median double J stent dwell time in our study was 4 weeks. The reason for these at first glance conflicting results is the reimbursement provisions of our health care system which only allow re-hospitalisation/re-intervention 18 days after the last hospital discharge. Other health care systems might allow earlier stent removal; whether this would change the results of spontaneous stone passage, however, cannot be definitely answered. Furthermore, it is unknown whether a longer interval after stent removal would improve the rate of spontaneous stone passage, increase the rate of adverse event, or even negatively influence secondary treatment: factors that should be known in order to better counsel patients.

The main limitations of the present study are inherent to its retrospective nature. However, we strictly adhered to our standardized institutional protocol and follow-up in all patients which might limit, but not exclude, relevant bias. In line with this main drawback, we were not able to obtain sufficiently strong data to assess whether symptomatic or asymptomatic urinary tract infections impact stone passage by the presence of ureteric mucosa/wall edema with possible impaired peristalsis. Another point of criticism is that patients included in this analysis did not additionally have relevant stone burden that required active stone treatment independent of the symptomatic ureteral stone. Nevertheless, we wanted to evaluate the chance of spontaneous ureteral stone passage after stent removal, another so far unknown factor that might influence individual stone and patient management.

Conclusions

Most patients (61%) passed their ureteral stone spontaneously after previous stent placement without the need for secondary intervention: 34% while the stent was indwelling, 27% within 24 h after stent removal. Following stent removal under local anesthesia, no severe adverse events occurred and renal colic only happened in 8% of patients, all of whom had no spontaneous stone passage. Thus, selection of suitable patients is crucial as the procedure can easily be performed in an outpatient setting. Our treatment strategy (decision tree) presented here incorporates stone location, stone size (< 6 mm), and stone movement (≥ 5 cm) while the stent is indwelling. It helps identify patients who are likely to pass their ureteral stone spontaneously following stent removal. These patients should be offered the opportunity to expel their ureteral stone spontaneously and thus avoid unnecessary surgery.

Author contributions ESG: data collection, manuscript writing, data analysis. TG: data collection, manuscript editing. MAF: data management, manuscript editing. PB: data analysis, manuscript editing. BK: manuscript editing. MDV: data analysis, manuscript editing. BR: project and protocol development, data management and collection, data analysis, manuscript writing and editing.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Statement of human rights 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. The study was conducted in accordance with the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) statement and approved by the Ethics Committee of the Canton Bern, Switzerland (protocol number: KEK-Be 2017-01698).

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

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