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What Is the Optimal Stenting Duration after Ureteroscopy and Stone Intervention? Impact of Dwell Time on Postoperative Emergency Department Visits

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Study Need and Importance: The AUA stone management guidelines recommend minimizing the duration of stenting after ureteroscopy to reduce morbidity, and stents with extraction strings may be used for this purpose. However, there are limited data on stenting dwell time and its impact on outcomes such as unplanned health care encounters. Using real-world practice data from the Michigan Urological Surgery Improvement Collaborative, we investigated the association between dwell time and string status on postoperative emergency department (ED) visits on the day of or day after stent removal.

What We Found: We analyzed 4,437 unilateral ureteroscopy and stenting procedures in nonpre-stented patients; 38.1% had an extraction string placed, and there was significant surgeon variation in the use of this method. Patients with extraction strings had shorter dwell times. Dwell time of 0-4 days was significantly associated with an increased risk of ED visit occurring around the time of stent removal. There was no statistically significant increase in risk of ED visits in patients with a string if dwell times were ≥5 days (see Figure).

Limitations: Data on the stent composition, size, and how the extraction string was managed were not available. Reasons why providers chose stents with strings were not captured, and it is possible that higher-risk patients or those with a history of stent intolerance were more likely to receive such stents. We are also unaware if the instruction to have a short dwell time is surgeon or patient driven, or because of stent-related symptoms.

Interpretation for Patient Care: In Michigan, ureteral stent dwell time of 4 days or less is associated with an increase in postoperative ED visits around the time of stent removal. In nonpre-stented patients undergoing ureteroscopy and stone intervention, we recommend a minimum dwell time of at least 5 days.

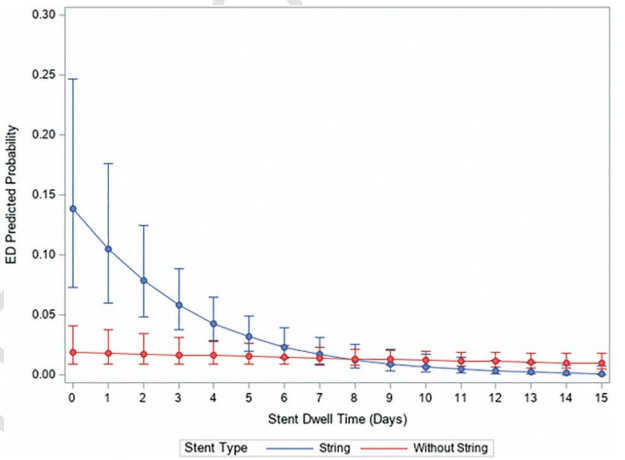

Figure. Predicted probability of a postoperative emergency department (ED) visit on the day of or day after stent removal, by stent dwell days and stent string use. Adjusted for age, sex, Charlson Comorbidity Index, stone location, and stone size with random effect for practice and urologist.

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What Is the Optimal Stenting Duration After Ureteroscopy and Stone Intervention? Impact of Dwell Time on Postoperative Emergency Department Visits

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Purpose: AUA stone management guidelines recommend stenting duration following ureteroscopy be minimized to reduce morbidity; stents with extraction strings may be used for this purpose. However, an animal study demonstrated that short dwell time results in suboptimal ureteral dilation, and a pilot clinical study showed this increases postprocedure events. Using real-world practice data we examined stent dwell time after ureteroscopy and its association with postoperative emergency department visits.

Materials and Methods: We used the Michigan Urological Surgery Improvement Collaborative registry to identify ureteroscopy and stenting procedures (2016-2019). Pre-stented cases were excluded. Stenting cohorts with and without strings were analyzed. Using multivariable logistic regression we evaluated the risk of an emergency department visit occurring on the day of, or day after, stent removal based on dwell time and string status.

Results: We identified 4,437 procedures; 1,690 (38%) had a string. Median dwell time was lower in patients with a string (5 vs 9 days). Ureteroscopy in younger patients, smaller stones, or renal stone location had a higher frequency of string use. The predicted probability of an emergency department visit was significantly greater in procedures with string, compared to without string, when dwell times were less than 5 days ($P < .01$) but were not statistically significant after.

Conclusions: Patients who had ureteroscopy and stenting with a string have short dwell times. Patients are at increased risk of a postoperative emergency department visit around the time of stent removal if dwell time is $\leq$4 days. We recommended stenting duration of at least 5 days in nonpre-stented patients.

Key Words: ureteroscopy, lithotripsy, morbidity

URETERAL stents are associated with flank pain, hematuria, and lower urinary tract symptoms in many patients.[1,2] For these reasons, the AUA stone management guidelines recommend the duration of stenting after ureteroscopy and stone intervention be minimized to reduce stent-related morbidity.[3] The AUA guideline panel recommended 3 to 7 days of stenting following uncomplicated ureteroscopy. This was based on expert opinion as there are limited data on stent dwell duration and its impact on outcomes.[4] For shorter stenting duration, urologists may use stents with extraction strings that allow for removal at home or nurse-led removal in the clinic.

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Ethics Statement: This study received Institutional Review Board approval (IRB No. HUM00054438).
Author Contributions: Conception and design: KRG, SD-N, AC, PY, BS, CD; Data analysis and interpretation: OOO, SD-N, AC, PY, BS, CD; Data acquisition: PY, SL, DW, CD; Critical revision of the manuscript for scientific and factual content: SD-N, AC, PY, SL, BS, DW, CD; Drafting the manuscript: KRG, OOO, SD-N, AC, PY, CD; Statistical analysis: OOO, SD-N, AC, PY, BS; Supervision: KRG, SL, BS, DW, CD.
Data Availability: The data sets generated during and/or analyzed during the current study are not publicly available due to contractual and funding reasons to keep the data confidential and deidentified. They are available from the corresponding author on reasonable request.
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Other reasons for using strings are if the use of a stent is equivocal or the patient is at high risk for being lost to follow-up.

Benefits of stents with extraction string are lower health care costs in terms of an office visit and procedure,[5] and increased patient convenience.[6-8] While studies have shown extraction strings are associated with adverse events such as dislodgment,[9] very few studies have assessed the relationship between stent dwell time and complications, especially the frequency of postoperative emergency department (ED) visits. In a pilot study assessing 3- vs 7-day dwell times in patients with strings, 3-day stenting resulted in more postprocedure events such as phone calls, clinic visits, and ED visits.[4] Furthermore, a recent porcine study found that the ureter is maximally dilated after 5 days of stenting,[10] and so it might be that suboptimal ureteral dilation results in spasm and pain. Based on these data, we explored stent dwell time outcomes in our quality improvement ureteroscopy registry in Michigan. We hypothesized that stent removal in patients with a short dwell time (most likely in patients with strings) may result in symptoms leading to patients seeking care in the ED.

Because of the lack of real-world practice data, we sought to understand surgeon-level variation for stenting, with and without extraction strings, in diverse groups within the Michigan Urological Surgery Improvement Collaborative (MUSIC). We assessed the relationship between dwell time, extraction string status, and risk of postoperative ED visit on the day of or day after stent removal. We determined if there is a minimum dwell time threshold related to ED visits. Our work serves to guide patient counseling, inform quality improvement interventions, and guideline recommendations.

METHODS

Data Source

MUSIC is a statewide quality collaborative in Michigan established in 2011, in partnership with Blue Cross Blue Shield of Michigan. The Reducing Operative Complications from Kidney Stones (ROCKS) initiative was started in 2016 and includes community and academic urology practices. ROCKS maintains a clinical registry of ureteroscopy cases performed in hospitals and ambulatory surgery centers, regardless of insurance type or status. Trained abstractors at each site prospectively record standardized data elements in a web-based registry, collecting information up to 60 days after ureteroscopy. Details on the ROCKS registry has been described previously.[11,12] Practices include those with resident involvement (academic), occasionally with a resident (hybrid), and sites with no residents (private). Each practice has obtained an exemption or approval by the local Institutional Review Board for participation in MUSIC.

Study Population

We identified 7,701 primary ureteroscopy and ureteral stenting procedures between June 2016-July 2019. ROCKS standardized collection procedures include patients $\geq$ 18 years, without a bilateral procedure, and excludes ureteroscopy occurring after percutaneous renal surgery. We excluded pre-stented procedures (n=2,666) or where pre-stenting was missing (n=62) and staged procedures (completed within 4 weeks of an ipsilateral ureteroscopy, n=406), as these may influence outcomes. Additionally, if stent category (string vs no string) was missing in the operative or clinic note, the procedure was excluded (n=130).

Outcomes and Statistical Analysis

Because patients with extraction strings are often the patients with short dwell times, and it would be hard to assess dwell time without this variable accounted for, we stratified the stenting procedures into 2 groups: (1) stent with string, (2) stent without string. We compared demographic and operative data between strata reporting frequency and proportions with chi-squared tests for nominal categorical variables, Mantel-Haenszel chi-square tests for ordinal variables, and medians with 25th and 75th percentiles using Wilcoxon rank-sum tests for continuous measures. Dwell time (days) was examined as a continuous variable.

We assessed variation of stenting, with and without extraction strings, in surgeons who had $\geq$ 10 cases. The proportion of procedures with an extraction string stent for each surgeon is displayed on a bubble chart to incorporate surgical case volume and a chi-square test was used to assess if this proportion was significantly different between surgeons. The proportion of string use was described by practice type (academic, private, or hybrid) with the median surgeon level proportion of string stents each practice type and tested using the Kruskal-Wallis rank test. The median stent dwell time by stent type for each surgeon was presented for surgeons who had $\geq$ 5 cases within the stent stratum.

To assess factors associated with dwell time, a linear regression model was used with dwell days as the dependent variable, fixed effects included age, gender, Charlson Comorbidity Index, stone location (renal, ureteral, or both), stone size, stent with string (yes/no), ureteral access sheath use, prior stone surgery, and a random intercept to account for intrasurgeon and intrapractice correlation for surgeon which is nested in a urology practice with an unstructured covariance structure.

The rate and reasons for all 30-day postoperative ED visits after ureteroscopy and stenting was assessed. Each ED visit can include multiple reasons. Our primary outcome of interest was the frequency and reasons for ED visits in patients who presented on the day of or day after stent removal among procedures where stent removal occurred within 30 days after ureteroscopy (N=3,332) and ED visit data were available (missing=27, final N=3,295). This endpoint and this population are used for description of ED visit rates by stent type with reasons. Additionally, the complete case data set (N=3,001, 294 (8.9%) excluded due to independent variable missing data) of this subset population was then used in the multivariable logistic model for the primary outcome.

A mixed logistic regression model was used to assess the odds of a postoperative ED visit on or the day after

stent removal with the primary predictors being stent with or without string, dwell time, and the interaction of stent type and dwell time. The model adjusted for age, gender, Charlson Comorbidity Index, stone location, and maximum stone diameter (continuous). The model included a random intercept to account for intrasurgeon and intrapractice correlation for surgeons who are nested in a urology practice with unstructured covariance structure The predicted probability of an ED visit based on dwell time and string status was plotted with 95% confidence intervals. Pairwise comparisons of, with string and without string, by dwell day were performed for dwell days 1-5 with significance assessed at .01 using the Bonferroni adjustment using contrasts to test these effects from the model. A sensitivity analysis was performed but excluding procedures that had a dwell time of 0 days. All statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, North Carolina), and statistical significance was set at .05 unless stated otherwise.

RESULTS

A total of 4,437 cases of primary ureteroscopy and stenting among 23 practices and 174 surgeons were analyzed. Of these, 1,690 (38%) had an extraction string. Patient and operative characteristics, and duration of stenting, for string and no string groups are compared in Table 1. Figure 1 provides the distribution of median dwell times per provider based on string status. Median dwell time with string was significantly shorter, 5 days, vs 9 days without. Significant factors impacting stent duration included string use, age, prior surgery, and use of ureteral access sheath (Supplementary Table 1, https://www.jurology.com). Procedures with a string were in younger patients, had higher frequency of prior stone surgery, lower frequency of ureteral stone location, and smaller stones. Patients with a string had a higher rate of postoperative alpha blocker prescription.

In the 103 surgeons with $\geq$ 10 cases, there was significant variation in performing ureteroscopy and stenting with a string. Surgeons practiced this from 0% to 100% of all their stenting cases (chi-square $P < .001$; Supplementary Figure, https://www.jurology.com). Surgeons using stents with a string with the greatest frequency had higher ureteroscopy volumes. However a proportion of surgeons, n=30 (29.1%), never used a string. Surgeons in academic practices used strings more frequently (median 34.7%) than those in hybrid (5.3%) or private practices (25.7%; $P = .01$).

Among the 4,437 stented procedures, 422 (9.6%) patients had a postoperative ED visit within 30 days of ureteroscopy. Patients with a string had a higher ED visit rate compared to those without a string

Table 1. *Clinical Characteristics of Patients Undergoing Ureteroscopy and Stenting, With and Without an Extraction String, in the Michigan Urological Surgery Improvement Collaborative*

	No string		String		*P* value
Patients stented, No. (%)	2,747	(61)	1,690	(38)	
Age, median (IQR), y	58.4	(46.1-68.0)	55.0	(41.8-65.2)	< .001[a]
Body mass index, median (IQR), kg/m^2 (missing=302)	29.5	(25.5-34.5)	29.6	(25.7-34.6)	.6[a]
Charlson Comorbidity Index, No. (%) (missing=2)					.19[b]
0	1,994	(73)	1,196	(71)	
1	409	(15)	264	(16)	
≥2	343	(12)	229	(14)	
Male gender, No. (%)	1,378	(50)	832	(49)	.5[c]
History of prior stone surgery, (No. (%) (missing=1,064)	822	(40)	575	(44)	.019[c]
SWL within 90 days of ureteroscopy, No. (%)	40	(1.5)	23	(1.3)	.8[c]
Stone location, No. (%) (missing=296)					< .001[c]
Renal	651	(26)	459	(28)	
Ureteral	1,505	(60)	862	(53)	
Renal and ureteral	373	(15)	291	(18)	
Stone size (missing=130)					
Median stone diameter, mm (IQR)	7	(5-9)	6.5	(5-9)	.006[a]
≤5	852	(32)	571	(35)	.019[b]
>5- ≤10	1,343	(50)	824	(50)	
>10	467	(18)	250	(15)	
Preoperative hydronephrosis, No. (%) (missing = 345)	1,759	(68)	1,042	(70)	.2[c]
Ureteral access sheath used, No. (%) (missing=79)	1,045	(39)	592	(36)	.056[c]
Were all stones basketed? No. (%) (missing = 1,067)	1,304	(63)	812	(62)	.6[c]
Postoperative alpha blocker, No. (%) (missing=580)	1,285	(54)	993	(67)	< .001[c]
Postoperative anticholinergic, No. (%) (missing=1,930)	561	(36)	318	(34)	.5[c]
Postoperative stent dwell time					
Dwell time, median (IQR), d	9	(6.5-14)	5	(4-7)	< .001[a]
Unknown dwell time, No. (%)	567	(21)	403	(24)	
Unknown reason, No. (%)					
Removed >60 d postureteroscopy	69	(2.5)	36	(2.1)	
Unknown due to missing data	498	(18)	367	(22)	

Abbreviations: IQR, interquartile range; SWL, shockwave lithotripsy.
[a] Wilcoxon rank test.
[b] Mantel-Haenszel χ^2 test.
[c] χ^2 test.

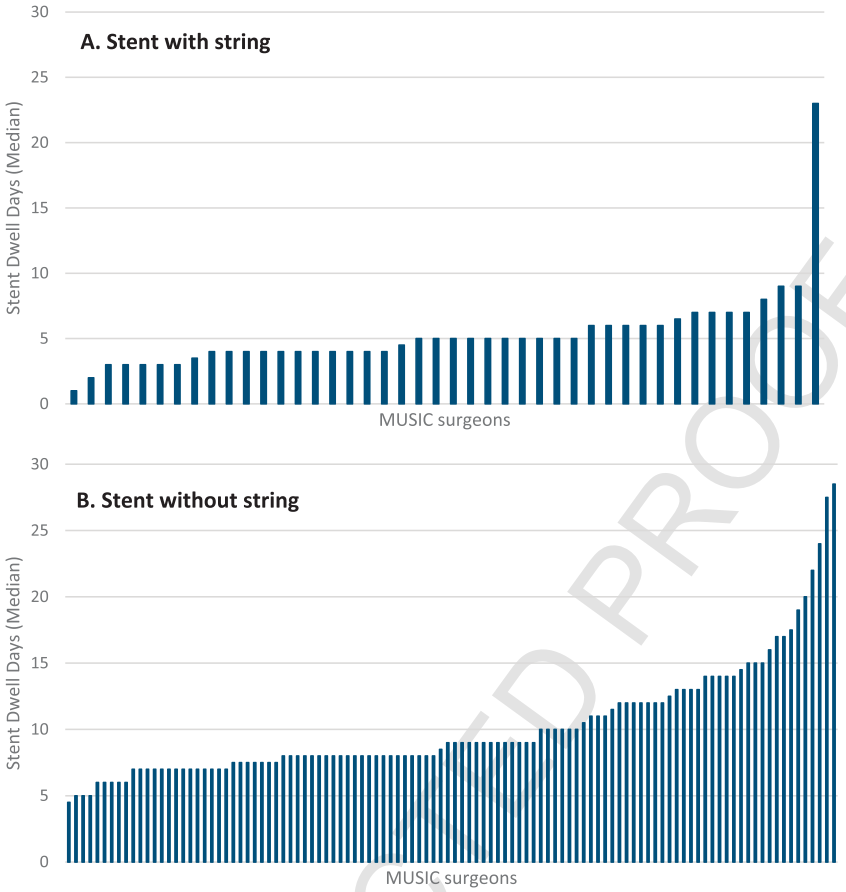

Figure 1. Median ureteral stent dwell time among surgeons performing ureteroscopy and stenting based on stent with string (A, N = 43) and stent without extraction string (B, N = 107). Each bar represents 1 surgeon; includes surgeons with ≥5 surgeries with the stent type. MUSIC indicates Michigan Urological Surgery Improvement Collaborative.

(13% vs 7.9%, $P < .001$). Table 2 details the reasons for 30-day ED visits.

In the subset of 3,295 procedures with stent dwell days ≤30 days and ED visit data, 317 (9.6%) had an ED visit within 30 days. One hundred six patients (3.2% of procedures; 33% of 30-day ED visits) presented to the ED on the day of or the day after stent removal (Table 3). Of these ED visits on the day or day after stent removal, 68 patients had string and 38 patients had no string (ED visit rate string patients 5.5% vs 1.9% no string, $P < .001$). As a percentage of all procedures in both cohorts in Table 3, frequency of flank pain was 3.7% and 1.3% in patients with and without a string, respectively ($P < .001$). Stent dislodgment was also higher in patients with a string (0.49%) vs without (0.05%; $P = .013$). Procedures with an ED visit on day of or day after stent removal and with a string had a 4-day (IQR: 2-5) median dwell time, and without a string had a 6-day (IQR: 4-12) median dwell time. In the subset with dwell time ≤ 30 days, 104 patients had an unplanned office visit with no statistical difference between no string (3.6%) vs string (2.8%; $P = .2$). In the same cohort, the ED visit rate among ED visits occurring anytime during the stent dwell time or on the day after stent removal was 6.4% without string vs 10.6% with string ($P < .001$).

After controlling for patient factors and provider on multivariable analysis in patients with stent dwell days ≤30 days, stenting with a string vs without a string have different associations with ED visits based upon dwell time (Interaction test: $P = .001$). Procedures with strings have higher ED visit rates early and the odds of ED visits decrease per day increase of dwell time (OR: 0.74; 95% CI [0.63-0.84]). Conversely, stents without string had odds of ED visit that did not significantly change with dwell time (OR: 0.96; 95% CI [0.89-1.03]; Supplementary Table 2, https://www.jurology.com). The adjusted predicted probability of an ED visit on the same day or day after stent removal was significantly greater in procedures with string, when dwell times were <5 days (pairwise tests: $P \leq .002$ for days 1-4) but were not statistically different after ($P = .02$ for day 5) with Bonferroni multiple comparisons adjustment (Figure 2). Sensitivity analysis excluding procedures with stent removal on the day of ureteroscopy (dwell time = 0), had similar results and conclusions would not differ. An additional sensitivity analysis that included surgeon rate of

Table 2. *Reasons for Presenting to the Emergency Department Within 30 Days of Ureteroscopy and Stenting According to String Status*

	No string (n = 2,723)	String (n = 1,669)	χ^2 *P* value[a]
Patients who had ED visit, No. (%)	214 (7.9)	208 (12.5)	< .001
Reasons for ED visit, No. (%)			
Urinary frequency	10 (0.37)	11 (0.66)	.17
Flank pain	115 (4.2)	129 (7.7)	< .001
Hematuria	53 (1.9)	35 (2.1)	.7
Fever	25 (0.92)	23 (1.4)	.15
Urinary tract infection	29 (1.1)	35 (2.1)	.006
Sepsis	12 (0.44)	5 (0.30)	.6
Peri-hematoma	0 (0)	1 (0.06)	.4
Renal failure	1 (0.04)	0 (0)	> .9
Cerebrovascular accident	1 (0.04)	0 (0)	> .9
Deep vein thrombosis	1 (0.04)	2 (0.12)	.6
Nausea	24 (0.88)	30 (1.8)	.008
Abdominal pain	16 (0.59)	14 (0.84)	.3
Dysuria	12 (0.44)	16 (0.96)	.036
Urinary retention	9 (0.33)	10 (0.60)	.19
Stent dislodgment	3 (0.11)	9 (0.54)	.014
Syncope	4 (0.15)	5 (0.30)	.3
Bladder pain	6 (0.22)	4 (0.24)	> .9
Obstructed stone	1 (0.04)	3 (0.18)	.16
Other	75 (2.8)	68 (4.1)	.017

Abbreviation: ED, emergency department.
Each visit may include multiple reasons.
[a] Fisher's exact *P* value is provided where 5 or fewer cases were indicated.

string use estimated that string use had greater odds of ED visit but the size of this effect differed by how often urologists use this method (Supplementary Table 3, https://www.jurology.com).

DISCUSSION

We studied the duration of stenting after ureteroscopy in patients with and without strings, and their relationship with postoperative ED visits in Michigan. Our study has several key findings. While there was significant surgeon variation, the extraction string method was used in approximately 4 in 10 stented patients. Patients with extraction strings had significantly shorter dwell times. The rate of ED visits on the day of stent removal or day after was higher in this group. In particular, dwell time of 0-4 days was significantly associated with an increased risk of ED visit occurring around the time of stent removal. There was no statistically significant increase in risk of ED visits in patients with a string if dwell times were $\geq$ 5 days.

Data on the impact of stent dwell time after ureteroscopy are limited, and our study provides real-world practice outcomes. Patients with a string had short dwell times. A survey reported that 44% of urologists indicated using a dwell time of 5-7 days, while only 4% scheduled stent removal within 48 hours of placement.[13] Paul et al is the only prior study assessing outcomes based on dwell time, and they analyzed 3- vs 7-day stent duration.[4] In 79 patients with strings, the 3-day cohort had significantly higher postprocedure-related events. Our multicenter findings are consistent with Paul et al, where short dwell times led to more postprocedure problems.

In a meta-analysis pooling 483 patients with a string, there were no significant differences in postprocedure events (which included ED visits), in comparison to patients without a string.[14] However, in the studies assessing outcomes when using strings, dwell times are much longer. Barnes et al studied 68 patients, of whom 33 were randomized to string, and all string patients had their stents removed at day 7.[6] In another randomized trial, stents were removed at day 10 in 74 patients with a string.[8] While other studies provide stent dwell times, no assessment between different dwell times and complications were performed.[15,16] The limited evidence base confirms the importance of our work to better understand this practice and determine if there is a minimum dwell time associated with adverse events. What is clinically practiced is based on anecdotal experience per urologist.

In contrast to a prospective clinical trial, the registry has limitations, but its advantage is that it captures data from a broad community-based perspective. We do not collect information on stent composition or size. Many operative notes lack information on the make of stent. We do not collect data on previous passed stones, number of procedures, or stent use, which could play a part in outcomes. MUSIC adds new data elements when it is important for QI interventions. Currently, MUSIC does not record how the string is managed—whether secured, allowed to dangle freely, if cut, or knots are retied. Prior studies have shown that the dislodgment rate is the same if the string is fixed (13.3%)[9] or kept free (15%).[6] While

Table 3. *Reasons for Postoperative Emergency Department Visits on the Day of or Day After Stent Removal, According to String Status*

	No string (n = 2,059)	String (n = 1,236)	χ^2 *P* value[a]
Patients who had ED visit, No. (%)	38 (1.9)	68 (5.5)	< .001
Reasons for ED visit, No. (%)			
Urinary frequency	3 (0.15)	1 (0.08)	> .9
Flank pain	27 (1.3)	46 (3.7)	< .001
Hematuria	8 (0.39)	10 (0.81)	.14
Fever	4 (0.19)	5 (0.4)	.3
Urinary tract infection	5 (0.24)	13 (1.1)	.005
Sepsis	0 (0)	2 (0.16)	.14
Nausea	4 (0.19)	10 (0.81)	.012
Abdominal pain	4 (0.19)	5 (0.4)	.3
Dysuria	4 (0.19)	5 (0.4)	.3
Urinary retention	3 (0.15)	5 (0.4)	.16
Stent dislodgment	1 (0.05)	6 (0.49)	.013
Syncope	0 (0)	2 (0.16)	.14
Bladder pain	4 (0.19)	3 (0.24)	> .9
Obstructed stone	0 (0)	2 (0.16)	.14
Other	10 (0.49)	19 (1.5)	.003

Abbreviation: ED, emergency department.
Includes those with stent removal within 30 days.
[a] Fisher's exact *P* value is provided where 5 or fewer cases were indicated.

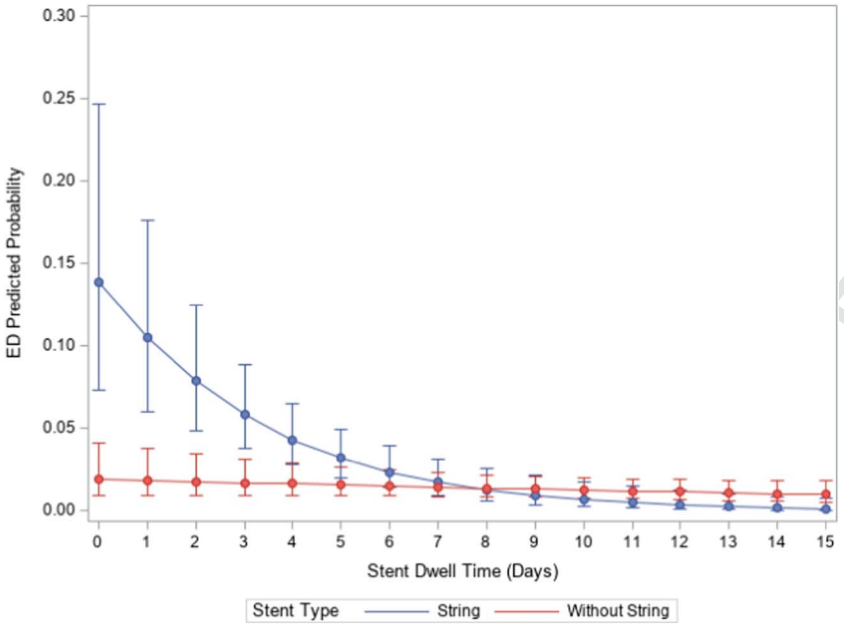

Figure 2. Predicted probability of a postoperative emergency department (ED) visit on the day of or day after stent removal by stent dwell days and stent string use. Adjusted for age, sex, Charlson Comorbidity Index, stone location, and stone size with random effect for practice and urologist.

MUSIC has created patient educational materials on ureteral stents including a collaboration with the Urology Care Foundation that includes information on how to remove the stent with string,[17] we do not know whether sufficient education was provided on how to manage the string.

MUSIC does not collect data on why providers use a stent with string. It is possible this practice might be higher in patients who have a history of pain or stent intolerance. We observed that higher-volume surgeons use this method, which could be related to clinic access for cystoscopic removal. Surgeons in academic practices used it more which might be related to resource availability, where residents can manage on-call issues and ED visits. We are also unaware if the instruction to have a short dwell time is surgeon or patient driven, or because of poor stent tolerance. We hypothesize that most patients are directed to have short dwell times because of the recognized issue of stent-related symptoms. Furthermore, despite MUSIC surgeons using a standardized postoperative pain protocol, and our work showing that a lack of opiates does not increase postoperative ED visits,[18] we recognize that pain management can vary which may have an impact on ED visits. While there were no differences in unplanned clinic visits, we did not assess telephone encounters/messages or visits to the primary care provider.

Limitations notwithstanding, our work examines stenting practices and dwell time with relationship to postoperative ED visits in a diverse population across multiple practices. Our findings may inform urologists on the optimal stenting duration. We recommend a dwell time of at least 5 days in nonpre-stented patients to avoid postoperative ED visits. In patients with short dwell times, the ureter may not be dilated, and when the stent is removed—either inadvertently or on purpose—it leads to pain. This threshold of 5 days is consistent with porcine data on ureteral dilation with stenting.[10] We acknowledge that stents with strings are an important method of stent deployment with advantages of lower removal costs with the greatest benefit being they are unlikely to be retained and forgotten. However, if patients remove their stent too early this may itself increase health care costs. Postoperative ED visits increase the cost of ureteroscopy by 50%.[19] Another factor to consider is that the decrease in ED visits in patients without a string has to be compared against the need for clinic (cystoscopy) in patients with no string/longer duration.

Future directions include educational efforts for patients on optimal stenting duration, and for those with strings guidance on how to prevent accidental removal and thus reduce events related to short dwell time. We could capture how often the stent is removed earlier than anticipated. Other unmeasured factors with clinic vs home removal need to be considered. Education at the time of clinic removal on what pain to expect may reduce ED visits, whereas patients who remove stents at home do not have that touchpoint. Phone calls from the care team on the day of stent removal could bridge this gap. Adjunctive measures such as administration of a nonsteroidal anti-inflammatory agent at the time of stent removal may reduce ED visits,[20] and be even

more important in patients with a short dwell time. Finally, prospective studies incorporating patient-reported outcomes are needed to confirm our findings, and better define factors that may increase the risk of complications. MUSIC will soon start a prospective clinical trial assessing patient-centric outcomes related to stent placement vs omission for uncomplicated ureteroscopy. Patients with strings will be included, and the study should provide more outcome data on stenting duration.

CONCLUSIONS

A ureteral stent dwell time of 4 days or less is associated with an increase in postoperative ED visits around the time of stent removal. In nonprestented patients undergoing ureteroscopy and stone intervention, we recommend a minimum dwell time of at least 5 days.

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EDITORIAL COMMENTS

The topics of ureteral stent duration after ureteroscopy as well as string vs no string have minimal published research. Clinical practice, then, is mostly guided by anecdotal experience per urologist. There is the ever-present question of balancing ease of care for the patient (cystoscopy to remove the ureteral stent is more involved than pulling on a string that is external to the patient's body) vs complications (we all know too well the pain of accidental early explantation of ureteral stents with phone

calls and extra medications and emergency department [ED] visits, and even takeback to the operating room for reinsertion). Oliver et al noted a 10% stent dislodgment rate with the strings.[1] Ghani et al in this paper look at stent dwell time related to string or not and ED visits.[2] In this paper, inter-surgeon variability in the practice of leaving stents on a string is evident and reflects probably the real-world practice. The authors found that ED visits were significantly greater with (1) the string ureteral stents and (2) if dwell time was less than 5 days. Both of these findings are intuitive but have never been confirmed in such a study. This is a great starting point to start addressing the topic, and future studies can help direct surgeon decision as to whether or not to leave the string on the stent at the end of a ureteroscopy stone procedure to optimize patient outcomes.

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The authors provide insightful data regarding the relationship between stent dwell time and postoperative emergency department visits in a cohort of over 4,000 patients, concluding that stents should be maintained for at least 5 days postureteroscopy.[1] These findings echo previous work from our institution demonstrating that patients with a 3-day stent dwell time are significantly more likely to have a postprocedure-related event than patients with a 7-day dwell time.[2] While the authors attempt to address multiple confounding surgical variables, the wide number of surgeons and surgical techniques, including stent use vs omission and stent type (which may affect pain[3]), most certainly introduces some level of unaccounted bias.

The data on whether an extraction string influences complications should be interpreted with caution. Extraction strings provide significant advantages by increasing convenience, decreasing cost,[4] and improving access, without increasing stent-related urinary symptoms or postoperative morbidity.[5] Nearly one-third of providers in this study never used strings (median 10%). What parameters drove providers to use a string? Is it possible that some may leave strings (for faster extraction) in those who have a history of stent intolerance? Similarly, could patients who were not tolerating their stent remove them earlier? Additionally, it is important not to underestimate the impact that in-person counseling and reassurance have on patient outcomes. Patients who present for stent removal (vs pulling at home) have an additional health care encounter that may limit subsequent emergency department visits.

The decision to use an extraction string and the duration of dwell time are multifactorial. In our practice, for patients where we choose to leave a stent, the optimal timing anecdotally appears to be in the 5-7−day timeframe. Extraction strings allow freedom to remove the stent during that window without limitations on patient transportation or clinic availability.

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