Variable Use of Postoperative Imaging Following Ureteroscopy: Results from a Statewide Quality Improvement Collaborative

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OBJECTIVE To understand patient and practice-level factors impacting postoperative imaging use after ureteroscopy (URS) for urinary stone disease.

METHODS The Michigan Urological Surgery Improvement Collaborative's Reducing Operative Complications from Kidney Stones (MUSIC ROCKS) initiative is a consortium of 52 urologists from 11 practices in Michigan. From June 2016 to July 2017, we prospectively collected clinical data for patients undergoing URS for stone treatment by MUSIC ROCKS participants. We measured the proportion of these patients who underwent US, AXR, and/or CT within the first 60 days after their procedure. We then assessed variation in the use of post-URS imaging according to patient characteristics and across MUSIC ROCKS practices.

RESULTS During the 13-month study period, we identified 2850 patients who were treated with URS for stone disease. Overall, only 47.6% of these patients underwent postoperative imaging. AXR was the most common modality used (55.0% of patients), followed by US (21.9%) and CT (11.1%). As shown in the Figure, use of post-URS imaging varied widely across participating practices (23.7%-73.6%; $P < .01$). Imaging receipt did not differ by patient age, gender, or insurance status. However, patients with more comorbidities, renal stones and those with larger stones were more likely to receive post-URS imaging ($P < .05$ for each comparison).

CONCLUSION Fewer than half of patients in Michigan undergo postoperative imaging after URS for stone disease. Moreover, there is substantial variation across providers in post-URS imaging use. These findings help identify opportunities to improve the quality of care for patients with urinary stone disease in the State. UROLOGY 136: 63−69, 2020.

Observational data suggest that the development of postoperative ureteral obstruction, which can be asymptomatic, occurs in up to 10% of ureteroscopy (URS) cases for upper tract urinary stone disease (USD).[1,2] Postoperative imaging can help to identify these patients, as they may need additional intervention. To this end, the American Urological Association published a clinical effectiveness protocol to help guide use of imaging after URS.[3] This protocol recommends abdominal X-ray (AXR) with or without renal ultrasonography (US) as first-line imaging after URS to assess treatment response and identify potential complications, though timing of imaging is not specified. In select situations, computed tomography (CT) may also be indicated.

Despite these recommendations, postoperative imaging is performed infrequently. A recent claims-based analysis found that only 45% of patients undergoing URS had postoperative imaging within 3 months of surgery, and only 61% had imaging within a year of their procedure.[4] While provocative, this study has at least 2 limitations. First, the investigators considered any abdominal imaging within a defined claims window, regardless of its intent, to determine utilization rates. This may overestimate actual postoperative imaging use. Second, by limiting the sample to privately insured adults, the study's findings may not be generalizable to the wider swath of patients who undergo URS. For this reason, additional work examining population-based trends in post-URS imaging is needed.

In this context, we analyzed data from the Michigan Urologic Surgery Improvement Collaborative's Reducing Operative Complications from Kidney Stones (MUSIC ROCKS) initiative. This is an all-payer, clinical registry

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that captures patients undergoing URS for USD in 1 of 30 urology practices from across the State. After identifying patients who underwent URS, we determined whether they received postoperative imaging within 60 days of their procedure. We then assessed variation in postoperative imaging use across participating practices. Finally, we fit multilevel models to understand factors independently associated with post-URS imaging receipt. These data help to inform future quality improvement efforts that aim to increase imaging use and enhance care quality for patients with USD.

METHODS

Data Source

The MUSIC is a Blue Cross Blue Shield of Michigan-funded consortium of community and academic urology practices in the State. To date, more than 90% of practicing urologists in Michigan participate in this quality improvement initiative. MUSIC maintains a prospective, validated clinical registry containing intraoperative and postoperative clinical data obtained through medical record review by trained abstractors at each participating site.[5]

In 2016, MUSIC launched ROCKS—a new quality improvement initiative focusing on USD. The goal of this initiative is to improve USD-related care in Michigan. During the ROCKS pilot phase (June 2016-December 2017), patients from 11 participating sites who underwent ambulatory surgery for USD (URS or shockwave lithotripsy) were prospectively entered into the ROCKS registry. In January 2018, 19 additional practices joined ROCKS, bringing the total number of participating sites to 30.

Study Population

From these practices, we identified patients 18 years of age and older who underwent URS between June 2016 and July 2017. We excluded patients who had an ipsilateral nephrostomy tube, underwent URS as a second-stage procedure following percutaneous nephrolithotomy, had synchronous bilateral procedures, or had concomitant nonstone related surgery at the time of URS.

Outcome

Our primary outcome was postoperative imaging receipt. Specifically, we assessed whether a patient received relevant genitourinary imaging (AXR, US, or CT) within 60 days of their URS procedure.

Statistical Analysis

For our initial analytical step, we determined the proportion of patients who underwent postoperative imaging within 60 days of surgery and by imaging modality. We then made bivariate comparisons between patients who received postoperative imaging and those who did not. In particular, we compared patients over a variety of sociodemographic and clinical factors, including age, gender, insurance type, body mass index, and level of comorbidity (assessed using the Charlson index[6]). We also considered several preoperative (stone size, stone location, preoperative urine culture status, whether a ureteral stent was placed prior to URS), intraoperative (need for ureteral dilation, ureteral access sheath use, whether basket stone extraction was performed or a ureteral stent was placed at the conclusion of the procedure, occurrence of any intraoperative complication) and postoperative factors (use of adjuvant alpha blocker therapy, occurrence of a complication within 30 days of surgery).

Next, we calculated variation in postoperative imaging use at the practice level. We stratified practices into terciles of low, medium, and high postoperative imaging use. For reliability purposes, only sites where at least 50 URS cases were performed over the study interval were included. Finally, we fit multilevel models to identify factors independently associated with postoperative imaging receipt.

We performed 2-sided significance testing and set a type-I error rate at 0.05. All the statistical analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC). The University of Michigan Institutional Review Board determined that this study was exempt from its oversight.

RESULTS

Over the study interval, 2850 patients underwent URS, less than half (47.6%) of whom received postoperative imaging. When imaging was performed, the most common modality used was AXR (55.0%), followed by US (21.9%), and CT (11.1%). Multiple imaging studies were obtained in 12.9% of these patients with AXR/US being the most frequent.

There were numerous patient factors associated with postoperative imaging receipt (Table 1). These included increasing level of comorbid illness, larger stone size, absence of preoperative hydronephrosis, positive preoperative urine culture, renal stone location (vs ureteral), and lack of preoperative stenting. Postoperative imaging was also more likely to be performed in patients who required ureteral dilation, in whom an ureteral access sheath was used, or who were prescribed adjuvant alpha blocker therapy.

Figure 1 shows nearly 3-fold variation in rates of postoperative imaging across participating sites that performed 50 or more URS procedures over the study interval (range, 23.7%-73.6%; P <.01). Differences between patient populations of practices that were high vs low utilizers of postoperative imaging are shown in Table 2. High utilizer practices tended to treat younger patients with higher levels of comorbid illness. Clinical characteristics that differed between high relative to low usage practices included absence of preoperative hydronephrosis, presence of preoperative positive urine culture, more common use of preoperative alpha blockers, renal stone location, and lack of a stent prior to surgery. Surgical characteristics including performance of ureteral dilation, use of a ureteral access sheath, stone fragment retrieval with a basket, stent placement, and lack of an intraoperative complication were more common among high imaging usage practices. Finally, high usage practices more commonly prescribed alpha blockers following surgery.

After accounting for observed differences in patient and practice-level factors, no demographic characteristics were independently associated with increased postoperative imaging use. During surgery, use of a ureteral access sheath was associated with 32% higher odds of postoperative imaging (OR, 1.32; 95% CI, 1.03-1.69). Finally, those patients prescribed an alpha blocker after surgery had 44% higher odds of receiving postoperative imaging (OR, 1.44; 95% CI, 1.15-1.80).

DISCUSSION

Using data from the MUSIC ROCKS registry, we found that only 47.6% of patients undergoing URS receive

Table 1. Factors associated with receipt of postoperative imaging following URS

Variable	Post-op Imaging Performed		*P*
	Yes	No	
Age, median (IQR)	55.8 (42.7-65.8)	54.4 (42.4-65.2)	.24
Largest stone size (mm), median (IQR)	7.0 (5.0-10.0)	6.0 (5.0-8.2)	<.01
	N(%)	*N*(%)	
BMI			
<30	691 (48.1)	746 (51.9)	.45
[30,35)	297 (47.1)	333 (52.9)	
[35,40)	168 (47.9)	183 (52.1)	
≥40	164 (52.6)	148 (47.4)	
Charlson comorbidity index			
0	898 (45.0)	1096 (55.0)	<.01
1	214 (50.4)	211 (49.6)	
≥2	232 (57.0)	175 (43.0)	
Insurance type			
Private	787 (48.6)	833 (51.4)	.24
Public	531 (46.9)	600 (53.1)	
None	23 (38.3)	37 (61.7)	
Gender			
Male	654 (46.9)	740 (53.1)	.47
Female	688 (48.3)	737 (51.7)	
Preoperative hydronephrosis			
Yes	742 (42.8)	992 (57.2)	<.01
No	444 (53.2)	390 (46.8)	
Preoperative urine culture			
Positive	222 (52.9)	198 (47.1)	<.01
Negative	921 (48.4)	983 (51.6)	
Not performed	202 (40.1)	302 (59.9)	
Alpha-blockers prior to surgery			
Yes	604 (49.8)	608 (50.2)	.14
No	700 (47.0)	789 (53.0)	
Stone location			
Both	147 (46.7)	168 (53.3)	<.01
Renal	512 (58.1)	369 (41.9)	
Ureter	593 (41.6)	834 (58.4)	
Unknown	93 (45.4)	112 (54.6)	
Stent prior to surgery			
Yes	421 (40.2)	627 (59.8)	<.01
No	922 (51.9)	853 (48.1)	
Ureteral dilation performed			
Yes	288 (57.4)	214 (42.6)	<.01
No	1041 (45.2)	1262 (54.8)	
Ureteral access sheath used			
Yes	508 (50.3)	502 (49.7)	.02
No	811 (45.8)	959 (54.2)	
Stone fragment retrieval			
Yes	519 (46.9)	588 (53.1)	.19
No	418 (49.9)	420 (50.1)	
Stent placed at time of surgery			
Yes	987 (48.4)	1051 (51.6)	.15
No	355 (45.4)	427 (54.6)	
Intraoperative complication			
Yes	22 (43.1)	29 (56.9)	.52
No	1323 (47.7)	1451 (52.3)	
Discharged with alpha-blockers			
Yes	832 (57.1)	625 (42.9)	<.01
No	449 (37.9)	736 (62.1)	

postoperative imaging. Overall, AXR was the most common imaging modality performed after URS followed by US and CT. Combination-modality imaging strategies were uncommon accounting for just 12.9% of cases. From a practice-level perspective, 3-fold variation existed between high and low imaging use groups. The only factors independently associated with receipt of postoperative imaging after taking into account patient- and practice-level factors were use of a ureteral access sheath and prescription of an adjuvant alpha blocker.

Our findings closely parallel those of Ahn et al who determined that 45% of patients in a national claims-based sample underwent imaging within 90 days of URS.[4] Moreover, the distribution of imaging modalities used in

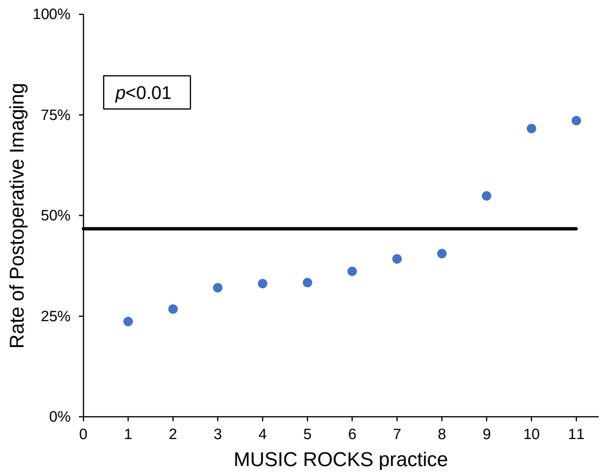

Figure 1. Practice-level variation in postoperative imaging use in those performing at least 50 URS. (Color version available online.)

their study was strikingly similar to our findings with a preponderance of patients being evaluated with AXR only. In their analysis, which relied on insurance claims from privately insured adults and their dependents, it was unclear whether imaging was performed for cause, that is, for follow-up specifically related to assessment of stone clearance following surgery, or imaging obtained for another indication. In contrast, the present study assessed urologist-directed imaging use which may avoid overestimation of imaging in the postoperative period. Furthermore, MUSIC ROCKS is an all-payer clinical registry incorporating a diverse cohort of large academic practices and small private groups thus increasing the generalizability of our results.

The fact that less than half of patients undergoing URS in the state of Michigan receive postoperative imaging is concerning. While some controversy exists with regard to optimal imaging frequency following URS,[7,8] there are compelling arguments that can be made for more routine postoperative imaging use. It is clear from several studies that the true stone-free rate following URS is approximately 50%-70%.[9,10] These residual stone fragments are not insignificant in that they often lead to stone-related events such as growth, stone passage, need for surgical intervention, or unplanned healthcare encounters.[11] Patients should be appropriately counseled as to their residual stone burden, something that cannot be done in an informed manner without postoperative imaging. In addition, patients with residual stone fragments may benefit from metabolic evaluation to prevent subsequent stone growth.[12]

Another factor suggesting the utility of routine postoperative imaging after URS is that persistence of ureteral obstruction after URS can occur in up to 10% of patients.[1,2] Indeed, the AUA clinical effectiveness protocol on imaging for USD indicates that in the setting of preoperative hydronephrosis, postoperative imaging with a renal US is necessary.[3] Though in many cases these patients with obstruction will be symptomatic, unrecognized or silent obstruction can potentially lead to renal loss. Cost-effectiveness studies have shown that although routine postoperative imaging is associated with a modest incremental cost increase relative to selective imaging, prevention of renal loss and its attendant morbidity justify this expense.[13] Interestingly, in the present study, presence of preoperative hydronephrosis was not associated with higher odds of postoperative imaging use. Concentrating on increasing imaging use in this population in accordance with the AUA clinical effectiveness algorithm may be a good first step toward improving overall postoperative imaging rates.

One factor that must be considered in view of our findings, and those of other investigators assessing the use of post-URS imaging is the perceived value of this imaging. Though compelling arguments can and have been made as far as assessing stone-free status and evaluating for persistent hydronephrosis, there does not seem to be a movement toward increased imaging use. This may be due to urologist's perception, despite guidelines, that routine imaging is not needed or useful in all cases. The impact of this cannot be assessed in the current manuscript but would certainly be a consideration for future study.

One clear advantage of our current study is the granular clinical details included in the registry which allows for assessment of predictors of postoperative imaging use. In our cohort in Michigan, use of a ureteral access sheath at the time of URS was associated with 32% higher odds of postoperative imaging. It is unclear why this is the case. Use of ureteral access sheaths, though potentially leading to ureteral injuries at the time of surgery,[14,15] have not been associated with an increase in postoperative hydronephrosis or ureteral stricture long term.[16-18] One possible reason for this observed finding in our study is that ureteral access sheath use could be a surrogate for case complexity, thus prompting more judicious imaging use in the postoperative period. The reason adjuvant alpha blocker prescription was associated with increased postoperative imaging after URS is less clear. This may also reflect a fragmentation (dusting) approach or case complexity which drove subsequent postoperative imaging.

Our findings must be viewed within the context of some limitations. First, we used a 60-day window to assess postoperative imaging use. It is possible that some providers may routinely perform imaging outside of this window thus underestimating the true rate. However, within MUSIC ROCKS, we provide tri-annual practice-level reports to physicians regarding their own imaging practices and have found that the majority of urologists perform imaging within this period. Another potential limitation is data validity. As a clinical registry, we rely on data abstraction from chart review. Since not all health systems and practices in the state of Michigan are fully integrated, there may be instances where imaging was performed and not available in the individual urologists' medical record. To address this, routine data validation audits are

Table 2. Differences between high usage and low usage practices for postoperative imaging

Variable	Low Usage Practice	High Usage Practice	*P*
Age, median (IQR)	55.5 (44.2-66.0)	54.1 (40.6-64.3)	<.01
Largest stone size (mm), median (IQR)	6.7 (5.0-9.0)	7.0 (5.0-10.0)	.07
	N(%)	N(%)	
BMI			
<30	617 (51.6%)	578 (48.4%)	.53
[30,35)	286 (54.6%)	238 (45.4%)	
[35,40)	141 (51.1%)	135 (48.9%)	
≥40	125 (49.4%)	128 (50.6%)	
Charlson comorbidity index			
0	930 (55.7%)	739 (44.3%)	<.01
1	172 (52.9%)	153 (47.1%)	
≥2	124 (37.7%)	205 (62.3%)	
Insurance type			
Private	730 (53.1%)	646 (46.9%)	.94
Public	464 (52.3%)	423 (47.7%)	
None	27 (51.9%)	25 (48.1%)	
Gender			
Male	623 (54.3%)	525 (45.7%)	.17
Female	603 (51.5%)	569 (48.5%)	
Preoperative hydronephrosis			
Yes	886 (62.7%)	526 (37.3%)	<.01
No	283 (42.2%)	387 (57.8%)	
Preoperative urine culture			
Positive	112 (33.3%)	224 (66.7%)	<.01
Negative	850 (53.0%)	755 (47.0%)	
Not performed	264 (69.1%)	118 (30.9%)	
Alpha-blockers prior to surgery			
Yes	460 (45.0%)	562 (55.0%)	<.01
No	686 (56.5%)	528 (43.5%)	
Stone location			
Both	165 (58.9%)	115 (41.1%)	<.01
Renal	265 (36.0%)	471 (64.0%)	
Ureter	696 (60.5%)	454 (39.5%)	
unknown	100 (63.7%)	57 (36.3%)	
Stent prior to surgery			
Yes	563 (66.1%)	289 (33.9%)	<.01
No	662 (45.1%)	807 (54.9%)	
Ureteral dilation performed			
Yes	147 (33.8%)	288 (66.2%)	<.01
No	1073 (57.2%)	803 (42.8%)	
Ureteral access sheath used			
Yes	424 (54.5%)	354 (45.5%)	.14
No	775 (51.2%)	738 (48.8%)	
Stone fragment retrieval			
Yes	474 (49.5%)	484 (50.5%)	.02
No	339 (43.8%)	435 (56.2%)	
Stent placed at time of surgery			
Yes	937 (55.2%)	761 (44.8%)	<.01
No	284 (45.9%)	335 (54.1%)	
Intraoperative complication			
Yes	32 (74.4%)	11 (25.6%)	<.01
No	1192 (52.3%)	1086 (47.7%)	
Discharged with alpha-blockers			
Yes	438 (34.1%)	845 (65.9%)	<.01
No	716 (74.1%)	250 (25.9%)	

conducted by MUSIC coordinating center staff to ensure its accuracy.

Limitations notwithstanding, results from our study help to better define the use of postoperative imaging after URS. By conducting this study using this large clinical registry, we were able to further illuminate patient and provider-level factors contributing to imaging use. Patients should be empowered by these findings and advocate for more routine imaging use both to establish stone-free status and dictate intensity of future follow-up. As providers, we should be cognizant of our own postoperative imaging rate. To this end, within MUSIC ROCKS, we provide tri-annual confidential reports including individual physician, practice, and collaborative-wide details on imaging rates following URS. Our goal moving forward is to continue to feed these data back to engaged collaborative members while also providing a forum which encourages continuous quality improvement.

CONCLUSION

Following URS, postoperative imaging is performed in less than half of patients in the state of Michigan within 60 days despite very clear guidelines and an accompanying algorithm provided by the American Urological Association dictating appropriate imaging use. Substantial variation exists across practices with regard to imaging use. These data add to a growing body of literature on this subject while adding granular detail on patient and practice level factors associated with imaging use. Taken as a whole, our findings indicate a potential quality of care concern. The engaged collaborative of urologists that make up MUSIC ROCKS are uniquely positioned to address such quality improvement initiatives. Efforts are already underway to better understand barriers to more widespread imaging use following URS as we seek to make Michigan among the best places in the world to receive kidney stone care.

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EDITORIAL COMMENT

As surgeons we have a responsibility to assess the outcomes of our commonly performed surgical procedures. For ureteroscopy (URS), now the most commonly utilized procedure for the management of renal and ureteral calculi,[1,2] imaging constitutes the primary means of objectively assessing surgical success and assuring absence of complications. The AUA addressed the need for and type of postoperative imaging in its 2012 Clinical Effectiveness Protocol for Imaging in the Management of Ureteral Calculous Disease.[3] Although there was insufficient evidence to support a full guideline on the topic, the Panel made recommendations based on limited evidence and expert opinion.

The Panel developed protocols for each of the clinical scenarios of spontaneous stone passage, URS and stone retrieval and URS and laser lithotripsy for which recommendations were predicated on whether the stone is radiolucent or radiopaque, was retrieved intact or fragmented and if patient is symptomatic or not. Although CT imaging is the ideal modality for identifying postoperative obstruction and residual fragments (RFs), the cost and radiation exposure associated with CT have discouraged its routine use post-URS and account for the recommendation of the Panel to use ultrasound and plain film radiography (AXR) to identify obstruction and/or RFs.

Although in most cases, postoperative obstruction is accompanied by ipsilateral flank pain, up to 2% of post-URS patients exhibit painless hydronephrosis.[4] As such, routine imaging in asymptomatic patients is aimed at identifying those with silent obstruction. While AXR alone is insufficient to identify obstruction, it can identify residual radiopaque stones. Recent studies indicate that stringent stone-free rates assessed by CT imaging are lower than previously reported, with stone-free rates of only about 50%-60%.[5-8] Furthermore, natural history studies on patients with RFs after URS have indicated a high likelihood of requiring repeat surgery (8%-29%), particularly when left with RFs >4 mm.[9-12] Consequently, in order to assure absence of obstruction and provide patients with appropriate expectations after surgery, stone-free status and urinary drainage must be adequately assessed. Although admittedly AXR underestimates stone-free rates compared to CT, the trade-off with regard to lower sensitivity in exchange for reduced radiation exposure seems acceptable.

In this issue of Urology, authors representing the 11-practice consortium, MUSIC ROCKS, assessed the utilization of postoperative imaging among 2850 patients undergoing URS in a diverse group of practices. Disappointingly, less than half the patients analyzed underwent imaging of *any* kind postoperatively and only 13% were imaged with the combination modality recommended in the AUA Clinical Effectiveness Protocol. These authors should be commended for bringing to light the widespread lack of radiographic follow-up after URS that likely occurs not just in Michigan but across the country. Not only will 2% of these patients experience silent obstruction and the potential for loss of kidney function, but it is likely that this group of patients is unaware of the presence of RFs that may ultimately cause pain, obstruction or need for further surgery. One wonders how these patients are counseled at their postsurgical follow-up visit and if they are unintentionally misled about the "success" of the procedure. By identifying the scope of the problem, the MUSIC ROCKS initiative raises awareness and offers the potential to implement a strategy to improve adherence to the recommended imaging protocol after URS. It is only by being honest with ourselves and our patients that we can identify and correct the shortcomings of any surgical intervention and provide better care for our patients.

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