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Ureteroscopy vs Shockwave Lithotripsy for Lower Pole Renal Stones: Treatment Variation and Outcomes in a Surgical Collaborative

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Study Need and Importance: AUA guidelines state clinicians should offer ureteroscopy (URS) or shockwave lithotripsy (SWL) to patients with symptomatic lower pole (LP) kidney stones ≤ 1 cm. This recommendation is based on evidence from expert centers, which may not reflect current real-world practice. We sought to assess differences in outcomes for patients with LP stones undergoing URS or SWL in the Michigan Urological Surgery Improvement Collaborative. We hypothesized that URS would have superior stone-free rates (SFRs) and no differences in 30-day postoperative emergency department visits or hospitalization.

What We Found: We identified 3645 unilateral URS or SWL procedures for ≤ 2 cm LP stones from 35 practices (209 surgeons); 2287 (62.7%) were SWL. There was significant variation in treatment modality based on practice and surgeon (Figure). For stones ≤ 1 cm, SFR was higher for URS (56% vs 39%; $P < .001$). There were no significant differences in SFRs for > 1 to 2 cm stones. Emergency department visits were higher after URS for ≤ 1 cm stones (OR: 2.95, 95% CI: 1.7-5.0) but not for > 1 to 2 cm stones (OR: 0.97, 95% CI: 0.4-2.2). URS for stones ≤ 1 cm was associated with hospitalization (OR: 4.67, 95% CI: 1.7-12.9) but not for stones > 1 to 2 cm (OR: 0.96, 95% CI: 0.4-2.2).

Limitations: Greater granularity related to patient/surgery-specific factors could provide additional insight related to treatment choice and outcomes. SFRs for URS are based on an imaging rate of 54% within 60 days. However, these rates are indicative of national practice patterns.

Interpretation for Patient Care: URS and SWL are not equivalent treatment options for LP stones, and treatment choice is predicted by the practice or urologist treating the patient. For stones ≤ 1 cm, URS was more effective but had greater morbidity. Both modalities demonstrated suboptimal efficacy. Our findings provide information that can assist with counseling patients for choosing the appropriate treatment for ≤ 2 cm LP stones.

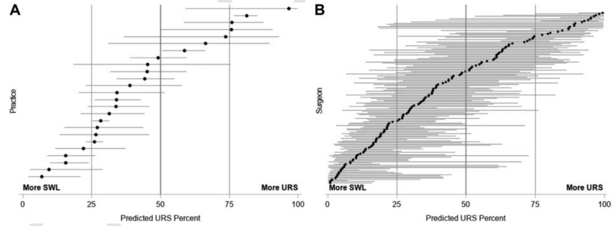

Figure. Predicted probability of having ureteroscopy (URS) vs shockwave lithotripsy (SWL) for (A) practices and (B) surgeons in the Michigan Urological Surgery Improvement Collaborative for lower pole (LP) stones ≤ 2 cm. The 95% CI is plotted from a multivariable model; adjustment factors include age, stone size, sex, insurance, Charlson comorbidity, urine culture, alpha blockers preoperatively, preoperative hydronephrosis, and prestented. (Practices with ≥10 cases and surgeons with ≥5 cases are only included.)

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Original Clinical Article

Ureteroscopy vs Shockwave Lithotripsy for Lower Pole Renal Stones: Treatment Variation and Outcomes in a Surgical Collaborative

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Purpose: AUA guidelines recommend ureteroscopy (URS) or shockwave lithotripsy (SWL) for lower pole (LP) stones $\leq$ 1 cm, while SWL is second line for stones $>$ 1 to 2 cm. In the era of increasing URS, there are limited data on the modality used and outcomes. We assessed treatment distribution, stone-free rates (SFR), and unplanned health care.

Materials and Methods: Using the Michigan Urological Surgery Improvement Collaborative registry, we identified URS and SWL cases for LP stones $\leq$ 2 cm (2016-2021). We assessed the frequency of patients receiving URS or SWL as a proportion of their LP treatment. A logistic model determined predictive probability of treatment modality. Differences in complete SFRs, postoperative emergency department visits, and hospitalizations were assessed by size ($\leq$1 cm, $>$1-2 cm), adjusted for patient factors and correlation within practice/provider.

Results: There were 3645 procedures from 35 practices (209 surgeons); 2287 (62.7%) had SWL. 80.2% of stones were $\leq$ 1 cm. There was variation in modality

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Author Contributions:
Conception and design: Dauw, Pimentel, Kim, DiBianco, Ghani, Hiller, Daignault-Newton.
Data analysis and interpretation: Seifman, Dauw, Stockall, Fernandez Moncaleano, Pimentel, DiBianco, Ghani, Kachroo, Daignault-Newton.
Data acquisition: Dauw, Wenzler, Stockall, Pimentel, DiBianco.
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based on practice ($P < .001$) and surgeon ($P < .001$). For stones ≤ 1 cm, the SFR was higher for URS (56% vs 39%; $P < .001$). There were no significant differences in SFRs for > 1 to 2 cm stones. Emergency department visits were higher after URS for stones ≤ 1 cm (OR: 2.95, 95% CI: 1.7-5.0) but not for > 1 to 2 cm stones (OR: 0.97, 95% CI: 0.4-2.2). URS for stones ≤ 1 cm was associated with increased hospitalizations (OR: 4.67, 95% CI: 1.7-12.9) but not for stones > 1 to 2 cm (OR: 0.96, 95% CI: 0.4-2.2).

Conclusions: In Michigan, SWL is the chosen modality for LP stones ≤ 2 cm. For smaller stones, URS was more effective but had greater morbidity. For larger stones, both modalities demonstrated suboptimal efficacy. Our work demonstrates the need for interventions to improve outcomes.

Key Words: quality improvement, nephrolithiasis, shock wave lithotripsy, retrograde intrarenal surgery, ureteroscopy, urolithiasis

For patients with symptomatic lower pole (LP) kidney stones ≤ 1 cm, the AUA stone management guidelines state clinicians should offer ureteroscopy (URS) or shockwave lithotripsy (SWL) as equal first-line treatment options.[1] This recommendation is based on a randomized clinical trial comparing URS and SWL in 67 patients which demonstrated no differences in the SFR for ≤ 1 cm stones.[2] For 1 to 2-cm LP stones, the AUA guides clinicians to not offer SWL as first-line therapy. This recommendation is based on the superiority of URS from a systematic review,[1,3] where for 1 to 2-cm LP stones, the median success rate for SWL was 58% compared with 81% for URS.[3] These guidelines, based on older studies from select centers, state that the URS outcomes likely represent select populations treated by expert surgeons.

Results from expert centers may not reflect real-world practice outcomes.[4] So far, studies comparing URS and SWL for LP stones are limited to small cohorts and report varying definitions of stone-free rate (SFR).[5] Many determine residual fragments (RFs) between 2 and 4 mm as successful treatment[4] despite evidence showing that patients with RFs > 2 mm are at risk of stone growth and secondary interventions.[6] Furthermore, most studies of URS vs SWL report nonstandardized complications such as hematuria or pain,[4] with no assessment of the impact on unplanned health care utilization, an important indicator of value and quality.[7] Importantly, with the changing landscape of stone treatment in North America, where URS utilization has increased over SWL,[8] there are limited data on modern treatment distribution and outcomes for LP stones.

For these reasons, we sought to assess differences in outcomes for patients with LP stones undergoing URS or SWL in the Michigan Urological Surgery Improvement Collaborative (MUSIC). We wanted to understand the treatment distribution among urologists and practices. Because of AUA guidance based on stone size categories, we assessed outcomes of < 1 cm and 1 to 2 cm LP stones. We hypothesized that URS would have superior complete SFRs for both stone size categories. Because a prior study determined similar postoperative unplanned care between URS and SWL for urinary stones,[9] we hypothesized that there would be no differences in 30-day postoperative emergency department (ED) visits or hospitalization. The goal of our work was to guide patient counseling, identify potential areas for quality improvement, and inform guideline recommendations.

METHODS

Data Source

MUSIC, established in partnership with Blue Cross Blue Shield of Michigan, is a quality consortium consisting of diverse academic and private practice groups across Michigan. The Reducing Operative Complications from Kidney Stones (ROCKS) initiative in MUSIC was started in 2016 and includes 35 community and academic urology practices. MUSIC ROCKS maintains a clinical registry of unilateral URS and SWL procedures performed in hospitals and surgery centers, regardless of insurance type. Staged procedures, defined as repeat ipsilateral surgery within 4 weeks, are excluded. Trained abstractors prospectively record standardized demographic, clinical, and outcomes data including unplanned health care (ED visits and hospitalization) occurring within 60 days of the procedure into a web-based clinical registry. Details on the ROCKS registry have been previously described.[10] Each MUSIC practice has obtained exemption or approval by their local institutional review board for participation.

Study Population

We identified patients aged 18 years and older who underwent unilateral URS or SWL to treat LP stones ≤ 2 cm (N = 7970) between 2016 and 2021. We excluded patients with stones in multiple locations in the kidney (N = 1776) and those with concomitant ureteral stone(s) (N = 2345), resulting in a 3645-procedure cohort.

Outcomes and Statistical Analysis

Stone size was defined as the maximum diameter based on preoperative imaging. Patients were stratified by LP stone size: ≤ 1 cm and > 1 to 2 cm. We compared demographic, clinical, and operative data between URS and SWL treatments using χ^2 tests for categorical variables and Wilcoxon rank sum tests for continuous measures. The comparison of the treatment groups and the descriptive data effect between the stone size strata were tested using a logistic model with treatment type as the outcome and fixed effects of stone size group, descriptive variable, and interaction of fixed effects with Wald χ^2 test of the interaction effect.

We assessed practice-level frequency of performing URS and SWL in practices with ≥ 10 total LP cases of URS and/or SWL and surgeon-level frequency in surgeons with ≥ 5 total cases. To determine which procedure was the most common procedure chosen, we assessed the frequency of patients receiving either URS or SWL as a proportion of their total LP stone treatment, adjusted for patient factors. A logistic model with treatment type as the outcome and fixed effects including practice, continuous age, continuous stone size (mm), sex, insurance (private/public/none), Charlson comorbidity (0/1/2+), urine testing (negative/positive/not performed; positive urine study is a urinalysis that is nitrite positive or a urine culture that has > 100,000 CFU), preoperative tamsulosin, preoperative hydronephrosis (yes/no/unknown), and indwelling stent was constructed. Variables included were expected to be considered in treatment-type decisions and are included to adjust for differences in a mix of these factors between practices and physicians to provide adjusted predicted probabilities of URS treatment. The predicted probability of URS and 95% CI from the model for each practice was plotted.

We assessed outcomes of URS and SWL by stone size category, including (1) postoperative ED visits within 30 days for any reason related to surgery, (2) unplanned hospitalization within 30 days, and (3) SFR within 60 days. SFR was defined as the absence of any RF on imaging reports (ultrasound, abdominal X-ray, CT, or any combination). The cohort for this end point includes 2331 procedures with imaging. Logistic mixed models used the complete case dataset, excluding cases because of missingness of independent variables, to model ED visits (N = 3573), unplanned hospitalization (N = 3573), and SFR (N = 2298). The ED visit and unplanned hospitalization models had fixed effects for treatment type (URS/SWL), and continuous stone size, continuous age, sex (male/female), comorbidity (0/1/2+), insurance (private/public/none), urine testing (negative/positive/not performed), preoperative hydronephrosis (yes/no/unknown), indwelling stent, stent placement, and intraoperative complication. Each model included a random intercept for physician nested in practice to account for correlation. Variables were included if they were expected to be associated with the outcome or affect the association between treatment type and outcome. Differences in the treatment effect by stone size (≤1/>1-2 cm) was added and tested. Similar methods were used for SFR with adjustment with the fixed effects above with preoperative tamsulosin. Wald χ^2 tests are reported for the treatment-type fixed effect and for stone size and modality interaction. Pairwise tests of treatment-type differences within the stone size group are reported from the models using contrasts. Predicted probabilities and odds ratios with 95% CIs for treatment type are reported overall and by stone size with interaction for each outcome. All analyses were performed using SAS 9.4 (SAS Institute), and statistical significance was set at 0.05. In addition, we have included the surgeon and practice as random effects in the model to account for surgeon effects that are not specifically measured but may affect the outcomes of a surgery.

RESULTS

A total of 3645 procedures for LP stones ≤ 2 cm were identified from 35 practices and 209 surgeons. Of these, 1358 (37.3%) were URS and 2287 (63%) were SWL. Table 1 compares demographic and clinical factors. Stones ≤ 1 cm accounted for 2924 (80%) cases. For LP stones ≤ 1 cm, 64% were treated with SWL. For LP stones > 1 to 2 cm, 56% were treated with SWL. For all stones ≤ 2 cm, patients undergoing URS had significantly greater comorbidity, BMI, and rates of female patients; antiplatelet therapy; urine studies positive for infection; and preoperative hydronephrosis. These differences persisted in patients with ≤ 1 cm, whereas the > 1 to 2 cm cohort found URS to have higher rates of female patients, comorbidity, positive preoperative urine studies, and preoperative hydronephrosis only. Reasons for prestenting are not captured in the registry. We found that 1.2% and 2.3% of patients undergoing URS and SWL for ≤ 1 cm LP stones, respectively, had a second procedure between 30 and 90 days after the first procedure. For LP stones > 1 to 2 cm, 0.94% and 3.2% of patients undergoing URS and SWL, respectively, had a second procedure between 30 and 90 days.

Several operative characteristics differed between stone size cohorts (Table 2). There were more prestented patients undergoing URS. Postoperative stenting rates were significantly higher after URS, with a higher frequency of antibiotic, alpha-blocker, and opiate prescriptions.

Twenty-five practices with ≥ 10 total URS and/or SWL cases and 146 surgeons with ≥ 5 total URS and/or SWL cases were identified to determine treatment modality variation (Figure 1). This showed significant variation in the adjusted predicted probability of performance of one modality vs the other based on the practice ($P < .001$) and surgeon ($P < .001$). More practices and urologists chose SWL (ie, performed >50% of 1 modality). Twelve surgeons (8.2%) performed URS exclusively and 12 surgeons (8.2%) performed SWL 100% of the time. Of the 209 surgeons, for URS, the median number of procedures/year per surgeon was 36 (IQR: 16-61). For SWL, the median number of procedures/year per surgeon was 15 (IQR: 5-31). Supplementary Table 1 (https://www.jurology.com) provides data on the practice type for surgeons.

Postoperative imaging was available for 622 (46%) URS and 1673 (73%) SWL cases. Figure 2 compares adjusted SFRs, postoperative ED visits, and hospitalization after URS and SWL. Table 3 provides SFR based on imaging. For stones ≤ 1 cm, the adjusted SFR was significantly higher after URS compared with SWL (59% vs 37%; $P < .001$). Adjusted SFRs between URS and SWL for > 1 to 2 cm stones were not significantly different (41% vs

Table 1. *Demographic and Clinical Data of Patients With Lower Pole Stones ≤ 2 cm Undergoing Ureteroscopy and Shockwave Lithotripsy in the Michigan Urological Surgery Improvement Collaborative*

	Total (n = 3645)			≤1 cm (n = 2924)			>1-2 cm (n = 721)			*P* value[a]
	URS (1358)	SWL (2287)	*P* value	URS (1039)	SWL (1885)	*P* value	URS (319)	SWL (402)	*P* value	< .001
Median age (IQR)	59 (48-69)	59 (49-68)	.7[b]	58 (46-68)	59 (48-67)	.6[b]	61 (51-71)	62 (52-70)	.5[b]	
Insurance, No. (%)			.001			.0013			.5	
Private	761 (56)	1418 (62)		583 (56)	1182 (63)		178 (56)	236 (59)		
Public	571 (42)	834 (37)		431 (42)	674 (36)		140 (44)	160 (40)		
None	21 (1.6)	25 (1.1)		20 (1.9)	22 (1.2)		1 (0.3)	3 (0.8)		
CCI, No. (%)			< .001			< .001			.005	
0	897 (66)	1688 (74)		704 (68)	1416 (75)		193 (61)	272 (68)		
1	237 (18)	380 (17)		168 (16)	290 (15)		69 (22)	90 (22)		
≥2	224 (17)	219 (9.6)		167 (16)	179 (9.5)		57 (18)	40 (10)		
BMI, No. (%)			< .001			< .001			.8	
≤30	597 (46.1)	1121 (52.0)		459 (46)	953 (54)		138 (45)	168 (45)		
>30	698 (53.9)	1035 (48.0)		530 (54)	826 (46)		168 (55)	209 (55)		
Sex, No. (%)			< .001			< .001			< .001	
Female	776 (57.1)	1068 (46.7)		593 (57)	918 (49)		183 (57)	150 (37)		
Male	582 (42.9)	1219 (53.3)		446 (43)	967 (51)		136 (43)	252 (63)		
On antiplatelet therapy, No. (%)	93 (6.9)	99 (4.4)	< .001	69 (6.7)	78 (4.2)	.027	24 (7.6)	21 (5.3)	.2	
Urine culture/urinalysis, No. (%)			< .001			< .001			< .001	
Positive	195 (14)	99 (4.3)		144 (14)	77 (4.1)		51 (16)	22 (5.5)		
Negative	876 (65)	1537 (67)		678 (65)	1275 (68)		198 (62)	262 (65)		
Not performed	286 (21)	650 (28)		218 (21)	532 (28)		70 (22)	118 (29)		
Preoperative hydronephrosis, No. (%)	309 (22.8)	190 (8.3)	< .001	238 (23)	144 (7.6)	< .001	71 (22)	46 (11)	< .001	
Median stone size, mm (IQR)	8 (5.5-10)	7 (6-9.6)	.15[b]	7 (5-8)	7 (5.6-8)	.021[b]	13 (12-15)	13 (12-15)	.5[b]	

Abbreviations: CCI, Charlson Comorbidity Index; SWL, shockwave lithotripsy; URS, ureteroscopy.
[a] χ^2 test of treatment group by stone size.
[b] Wilcoxon rank sum test.

29%, *P* = .051). Multivariable analyses found URS had increased odds of stone-free status overall (OR: 2.16, 95% CI: 1.6-3.0), and this effect was not significantly different by size (interaction *P* = .11).

Multivariable analyses (Table 4) also found significantly increased odds of having an ED visit after URS for stones ≤ 1 cm (OR: 2.96, 95% CI: 1.7-5.0) but not stones > 1 to 2 cm (OR: 0.96, 95% CI: 0.42-2.22); this effect was different between stone size groups (interaction *P* value = .006). Multivariable analyses found significantly increased odds of having a hospitalization with URS for stones ≤ 1 cm (OR: 4.67, 95% CI: 1.7-12.9) but not stones > 1 to 2 cm (OR: 1.44, 95% CI: 0.36-5.75); this effect was not different between stone size groups (interaction *P* value = .11). Supplementary Tables 2 and 3 (https://www.jurology.com) lists reasons for ED visits and hospitalizations, respectively.

DISCUSSION

We examined treatment distribution and outcomes for patients with LP stones ≤ 2 cm undergoing URS or SWL among diverse practices in Michigan. Our work has several key findings. While there was significant variation in the predicted probability of

Table 2. *Operative Data of Patients With Lower Pole Stones ≤ 2 cm Undergoing Ureteroscopy and Shockwave Lithotripsy in the Michigan Urological Surgery Improvement Collaborative*

	Total (n = 3645)			≤1 cm (n = 2924)			>1-2 cm (n = 721)		
	URS (1358)	SWL (2287)	*P* value[a]	URS (1039)	SWL (1885)	*P* value[a]	URS (319)	SWL (402)	*P* value[a]
Prestented, No. (%)	385 (28)	168 (7.4)	< .001	299 (29)	124 (6.6)	< .001	86 (27)	44 (11)	< .001
Ureteral dilation performed, No. (%)	259 (19)	n/a	n/a	191 (18)	n/a	n/a	68 (21)	n/a	n/a
Ureteral access sheath, No. (%)				504 (49)			207 (66)		n/a
Intraoperative complication, No. (%)	20 (1.5)	5 (0.2)	< .001	13 (1.3)	5 (0.3)	.002	7 (2.2)	0 (0)	.003
Failed URS	0 (0)	1 (0.04)		0 (0)	1 (0.05)		0 (0)	0 (0)	
Bleeding	13 (0.96)	0 (0)		9 (0.87)	0 (0)		4 (1.3)	0 (0)	
Perforation	2 (0.15)	0 (0)		2 (0.19)	0 (0)		0 (0)	0 (0)	
Other	3 (0.22)	3 (0.13)		0 (0)	3 (0.16)		3 (0.94)	0 (0)	
Anesthesia related	2 (0.15)	1 (0.04)		2 (0.19)	1 (0.05)		0 (0)	0 (0)	
Stent placed, No. (%)	1002 (74)	42 (1.9)	< .001	721 (70)	24 (1.3)	< .001	281 (88)	18 (4.5)	< .001
Prescribed antibiotics, No. (%)	423 (34)	392 (21)	.18	308 (33)	321 (21)	< .001	115 (40)	71 (23)	< .001
Prescribed alpha-blocker, No. (%)	727 (59)	867 (47)	< .001	549 (58)	716 (46)	< .001	178 (62)	151 (48)	< .001
Prescribed opiates, No. (%)	594 (50)	1032 (59)	< .001	467 (51)	850 (59)	< .001	127 (47)	182 (59)	.004

Abbreviations: n/a, not applicable; SWL, shockwave lithotripsy; URS, ureteroscopy.
[a] χ^2 test.

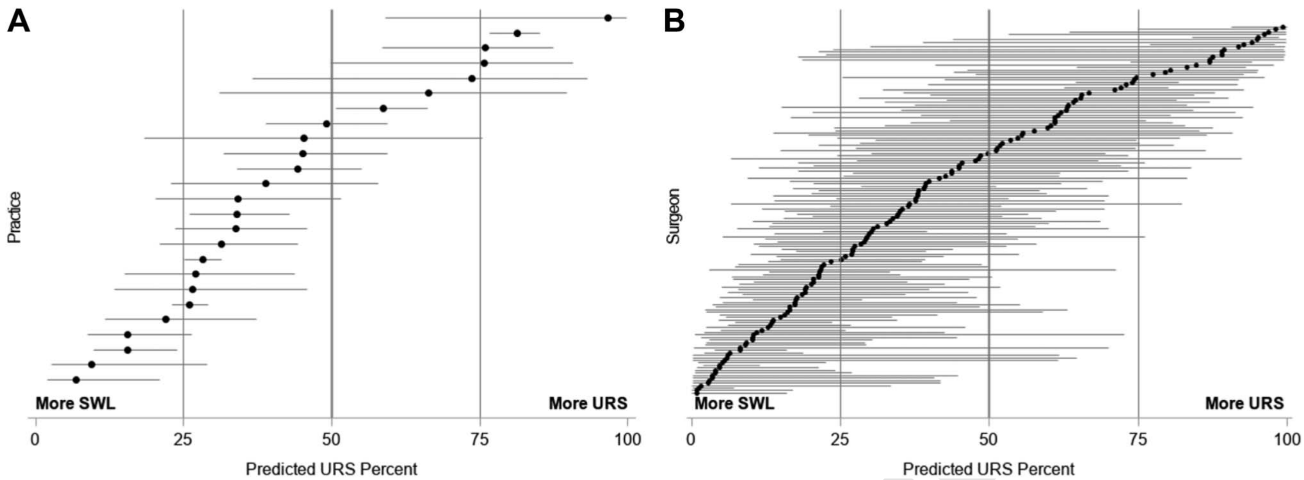

Figure 1. Predicted probability of having ureteroscopy (URS) vs shockwave lithotripsy (SWL) for (A) practices and (B) surgeons in the Michigan Urological Surgery Improvement Collaborative for lower pole (LP) stones $\leq$ 2 cm. The 95% CI is plotted from a multivariable model; adjustment factors include age, stone size, sex, insurance, Charlson comorbidity, urine culture, alpha blockers preoperatively, preoperative hydronephrosis, and prestented. (Practices with $\geq$10 cases and surgeons with $\geq$5 cases are only included.)

treatment modality, SWL was the most commonly used treatment, including for LP stones 1 to 2 cm size, which is not consistent with AUA guidelines. URS had higher unplanned health care utilization for stones $\leq$ 1 cm but not for stones > 1 to 2 cm. Finally, the SFR for URS was superior compared with SWL, and this difference was greatest for LP $\leq$ 1 cm. For stones > 1 to 2 cm, both modalities had suboptimal efficacy. Collectively, these findings demonstrate that in real-world practice, URS and

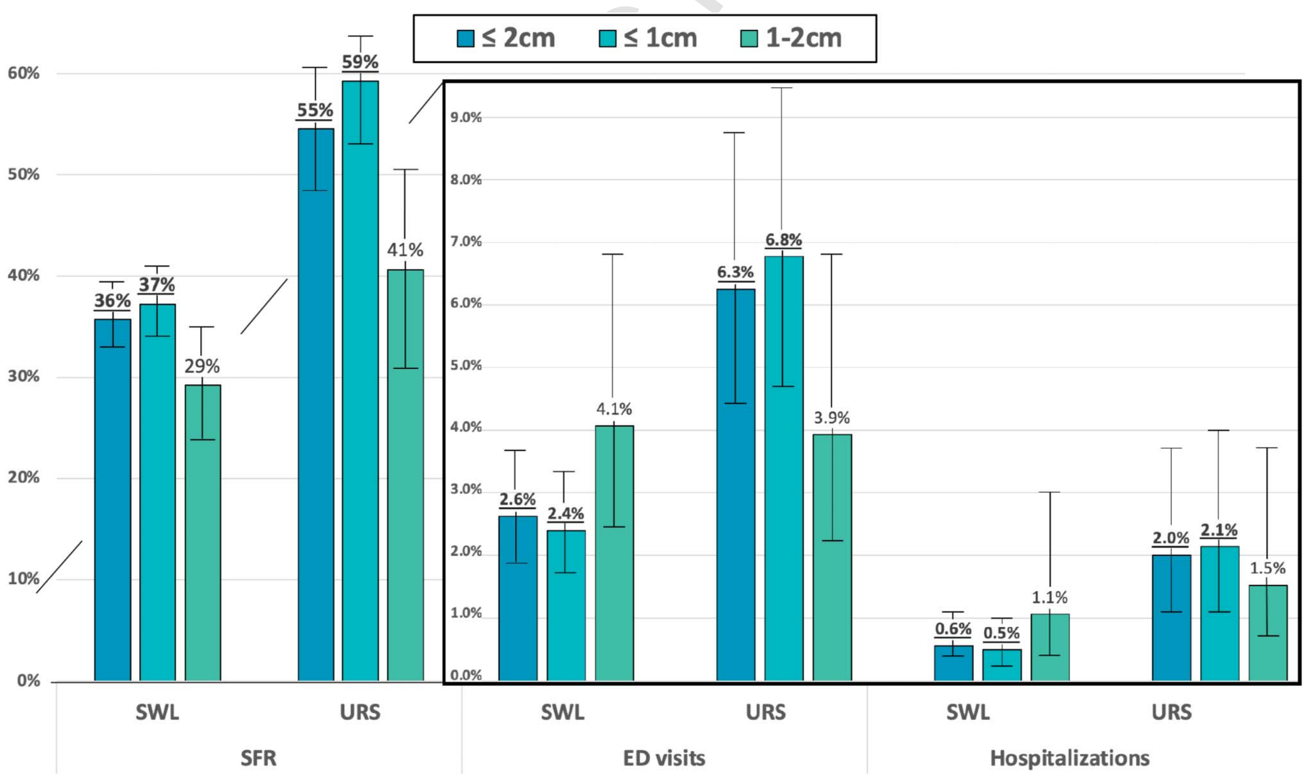

Figure 2. Stone-free^ and unplanned health care utilization* adjusted rates for patients with lower pole (LP) stones $\leq$ 2 cm undergoing ureteroscopy (URS) and shockwave lithotripsy (SWL) in the Michigan Urological Surgery Improvement Collaborative. Underline indicates clinical significance. *Adjusted for stone size, age, sex, comorbidity, insurance, urine testing, preoperative hydronephrosis, indwelling stent, stent placement, and intraoperative complication. ^Adjusted for stone size, age, sex, comorbidity, insurance, urine testing, preoperative hydronephrosis, indwelling stent, stent placement, intraoperative complication, and preoperative tamsulosin. ED indicates emergency department; SFR, stone-free rate.

Table 3. *Stone-Free Rates by Imaging Type for Patients With Lower Pole Stones ≤ 2 cm Treated With Shockwave Lithotripsy vs Ureteroscopy in the Michigan Urological Surgery Improvement Collaborative*

	≤1 cm		>1-2 cm	
Imaging type	URS, No. (%)	SWL, No. (%)	URS, No. (%)	SWL, No. (%)
KUB	120 (62)	375 (43)	22 (35)	56 (30)
US	87 (56)	54 (35)	16 (33)	5 (14)
US and KUB	21 (57)	64 (32)	8 (47)	15 (33)
CT	21 (46)	9 (18)	2 (17)	3 (27)
CT and KUB	0	3 (21)	2 (50)	1 (20)
CT and US	4 (31)	1 (10)	1 (20)	0
CT and US and KUB	1 (13)	4 (33)	0	1 (25)

Abbreviations: SWL, shockwave lithotripsy; URS, ureteroscopy; US, ultrasound.

SWL are not equally effective options, especially for LP stones ≤ 1 cm, because there is a trade-off between efficacy and morbidity.

Our study demonstrated that patients had a higher probability of undergoing SWL vs URS for LP stones ≤ 2 cm. Similar to prior work, the implications of our significant variability in predictive probability findings is that modality choice is not explained by clinical factors alone.[11] Worldwide data demonstrate increasing utilization of URS at the expense of SWL for the treatment of nephrolithiasis over the past 20 years.[8] Medicare data reveal regional variation in URS and SWL utilization, favoring URS.[12] However, practice and surgeon-level variation in these treatment modalities for patients with LP stones has not been previously reported. A survey from Switzerland showed high guideline-concordant care for LP stone treatment, with URS being the preferred treatment choice for stones > 1 to 2 cm.[13] However, what providers say they do and what they practice may be entirely different.

Understanding potential biases that influence treatment choice is important as appropriate patient selection may influence outcomes. A survey of AUA urologists revealed that surgeon characteristics of community practice setting, surgeon experience, increasing years in practice, and lithotripter ownership significantly affected surgeon SWL treatment selection.[14] With extreme ranges of modality use, clinician and/or practice preference, along with other unmeasured factors, may weigh

Table 4. *Multivariable Models Comparing Odds of Treatment Efficacy and Unplanned Health Care Use for Patients With Lower Pole Stones ≤ 2 cm Treated With Shockwave Lithotripsy vs Ureteroscopy in the Michigan Urological Surgery Improvement Collaborative*

	Adjusted[a] odds ratio	95% CI	*P* value	Interaction test
Efficacy (stone-free)[a]				
LP stones ≤2 cm				
URS vs SWL	2.16	1.55-3.02	*< .001*	
LP stones ≤1 cm vs >1-2 cm				0.11
LP stones: ≤1 cm				
URS vs SWL	2.46	1.74-3.47	*< .001*	
LP stones: >1-2 cm				
URS vs SWL	1.66	1.00-2.77	.051	
Postoperative 30-d ED visit[b]				
LP stones ≤2 cm				
URS vs SWL	2.47	1.48-4.13	*< .001*	
LP stones ≤1 cm vs >1-2 cm				*0.007*
LP stones: ≤1 cm				
URS vs SWL	2.95	1.74-5.03	*< .001*	
LP stones: >1-2 cm				
URS vs SWL	0.96	0.42-2.22	.9	
Postoperative hospitalization[b]				
LP stones ≤2 cm				
URS vs SWL	3.63	1.43-9.23	*.007*	
LP stones ≤1 cm vs >1-2 cm				0.11
LP stones: ≤1 cm				
URS vs SWL	4.67	1.70-12.9	*.003*	
LP stones: >1-2 cm				
URS vs SWL	1.44	0.36-5.75	.6	

Abbreviations: ED, emergency department; LP, lower pole; SWL, shockwave lithotripsy; URS, ureteroscopy.
[a] Adjustment variables include age, sex, comorbidity, insurance, urine testing, preoperative tamsulosin, preoperative hydronephrosis, prior stent, stent placed, and intraoperative complication.
[b] Adjustment variables include age, sex, comorbidity, insurance, urine testing, preoperative hydronephrosis, prior stent, stent placed, and intraoperative complication.

heavily on treatment choice. MUSIC clinical registry data are deidentified and practices/surgeons are not able to be categorized by ownership models; however, understanding the impact of this is an opportunity for further study. We feel there may be inherent bias on what patients receive, based on the provider, leading to such variation. Our work motivates others to look at their data and see if they have similar findings as to what we have seen in Michigan. A necessary step toward addressing surgical variation is to strengthen the evidence base. Physicians need better access to data on practice patterns. One way is to foster collaborations that facilitate comparative feedback on patterns of care relative to existing guidelines and their peers, as well as learning opportunities that can reduce variation in the delivery and outcomes of care.[15] This is what MUSIC aims to do.

We found a significant increase in postoperative ED visits and hospitalization after URS compared with SWL. Prior studies have not demonstrated significant differences in postoperative complications between SWL and URS for LP stones $\leq$ 1 cm.[5] Complication reporting typically excludes aspects of the patient experience that contribute to morbidity. Although it is evident from our data that these modalities offer different risk and benefit profiles. Patients may have treatment goals that align with certain aspects of these procedures. For example, the unlikely need for a ureteral stent with SWL may be 1 reason it is a popular treatment choice regardless of stone size.[14] While our SFRs are low based on a strict definition of zero fragments, studies based on CT data reveal complete SFRs after URS for renal stones are also in the range of 55% to 60%.[16]

While we found URS efficacy to be superior to SWL, especially for < 1 cm stones, SFRs were lower than what has been noted in the literature. The AUA guidelines report a SFR of 81% for LP stones < 2 cm treated with URS and cite a meta-analysis that is unpublished.[1] Recently, a meta-analysis demonstrated SFRs for URS ranging from 52.3% to 100%, but many of these studies provide varying definitions of stone free.[17] Expert opinion has questioned the accuracy of reported success rates for URS even among high-volume centers, including the limitations of ultrasound in assessing stone size.[18] Our work indicates that outcomes in community and academic practices in Michigan using complete stone-free criteria may not reflect results reported by select expert centers.[19]

To our knowledge, this is the largest study on outcomes of URS and SWL for LP stones. Nevertheless, there are several limitations. Clinical reasoning for treatment choice is not captured. Whether some practices/surgeons referred patients with LP stones to tertiary centers is unknown. We suspect this may be possible but the magnitude is small. We also do not collect data on factors that could affect treatment success such as infundibulopelvic angle, stone density, lithotriptor, or URS techniques such as stone repositioning.[20,21] The SFRs for URS are based on an imaging rate of 54% within 60 days. However, our imaging rates are indicative of current national practice patterns.[22] Furthermore, complete SFRs are suboptimal, a substantial proportion of these patients have RFs 1 to 2 mm, which are unlikely to have long-term clinical consequences.[23] We also do not take account of patient-reported outcomes, and comparison of treatment satisfaction after URS and SWL for patients with LP stones has not been studied. This is now a focus in our collaborative.

Our work has several implications. Because our data include cases from 2020 to 2021, which were affected by the COVID-19 pandemic, we must address if this could affect procedural choice. MUSIC data showed that both URS and SWL rates decreased during this time. URS cases decreased less than SWL with no difference in postoperative ED visit rates.[24] Our findings provide information that can help with counseling patients for choosing the appropriate treatment modality for LP stones. While postoperative imaging rates after URS were lower than those for SWL in this work, they also provide real-world evidence that both SWL and URS have significant room for improvement. If excellent SFRs are a priority, percussion inversion therapy after SWL as well as stone repositioning and suction instrumentation have been shown to significantly increase SFRs.[21,25,26] One intervention in MUSIC we have performed is address URS technical aspects for LP stone treatment in a teaching webinar. Furthermore, these patients may be better treated with percutaneous techniques, especially in the era of miniaturized techniques having less morbidity.[17,27] Our work emphasizes the need for high-quality randomized clinical trials to address this clinical scenario.

It has been shown that patients with stone disease place significant importance on their urologist's treatment recommendation.[28] Therefore, if only 1 treatment modality is performed, efforts to understand the extent of shared decision-making represents an area for quality improvement. Given the variation in practice demonstrated in this study, we have developed a clinical decision aid that takes the patient through URS and SWL and helps a patient align their management with their treatment preferences.[29] Going forward, by collecting data on patient-reported outcomes, unplanned health care utilization, and stone treatment success, we have the opportunity to develop a composite outcome metric that provides a more nuanced assessment of stone intervention success. This, if integrated with machine learning, may allow patients to select the treatment choice that suits their preferences, priorities, and risk profile.[30]

CONCLUSIONS

Despite significant variation in the use of URS and SWL for LP stones $\leq$ 2 cm in Michigan, SWL had the greatest selection probability. Our findings demonstrate that URS and SWL are not equal first-line treatment options. For LP stones $\leq$ 1 cm, URS has higher SFRs but with greater unplanned post-operative health care utilization. For 1 to 2 cm LP stones, there were no differences between SWL and URS in efficacy or ED visits. Our work highlights the need for interventions to address the morbidity associated with URS in patients with LP stones $\leq$ 1 cm and significantly improve the treatment efficacy for patients with 1 to 2 cm LP stones.

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