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Outcomes of Shock Wave Lithotripsy and Ureteroscopy for Treatment of Pediatric Urolithiasis

Rohit Tejwani[#], **Hsin-Hsiao S. Wang**[#], **Steven Wolf**, **John S. Wiener**, and **Jonathan C. Routh**[†]
Duke University School of Medicine (RT, HHSW, JSW, JCR), and Division of Urologic Surgery (HHSW, JSW, JCR) and Department of Biostatistics and Bioinformatics (SW), Duke University Medical Center, Durham, North Carolina

[#] These authors contributed equally to this work.

Abstract

Purpose: Shock wave lithotripsy has been commonly used to treat children with renal and ureteral calculi but recently ureteroscopy has been used more frequently. We examined postoperative outcomes from these 2 modalities in children.

Materials and Methods: We reviewed linked inpatient, ambulatory surgery and emergency department data from 2007 to 2010 for 5 states to identify pediatric admissions for renal/ureteral calculi treated with shock wave lithotripsy or ureteroscopy. Unplanned readmissions, additional procedures and emergency room visits were extracted. Multivariate logistic regression using generalized estimating equations to adjust for hospital level clustering was performed.

Results: We identified 2,281 admissions (1,087 for shock wave lithotripsy and 1,194 for ureteroscopy). Ages of patients undergoing ureteroscopy and those undergoing shock wave lithotripsy were similar (median 17.0 years for both cohorts, $p = 0.001$) but patients were more likely to be female (63.4% vs 54.7%, $p < 0.0001$), to be privately insured (69.8% vs 62.2%, $p < 0.0005$) and to have a ureteral stone (81.0% vs 34.8%, $p < 0.0001$). Patients undergoing ureteroscopy demonstrated a lower rate of additional stone related procedures within 12 months (13.6% vs 18.8%, $p < 0.0007$) but a higher rate of readmissions (10.8% vs 6.3%, $p < 0.0002$) and emergency room visits (7.9% vs 4.9%, $p < 0.0036$) within 30 days postoperatively. On multivariable analysis patients undergoing ureteroscopy were nearly twice as likely to visit an emergency room within 30 days of the procedure (OR 1.97, $p < 0.001$) and to be readmitted to inpatient services (OR 1.71, $p < 0.01$).

Conclusions: Ureteroscopy is now used more commonly than shock wave lithotripsy for initial pediatric stone intervention. Although repeat treatment rates did not differ between procedures,

[†]Correspondence: Division of Urologic Surgery, Duke University Medical Center, DUMC 3831, Durham, North Carolina 27710 (telephone: 919-684-6994; FAX: 919-681-5507; e-mail: jonathan.routh@duke.edu).

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ureteroscopy patients were more likely to be seen at an emergency room or hospitalized within 30 days of the initial procedure.

Keywords

lithotripsy; nephrolithiasis; postoperative complications; ureteroscopy; urolithiasis

A growing body of literature suggests that the prevalence of pediatric urolithiasis in the United States is increasing.[1–3] We recently found the economic impact of pediatric urolithiasis to be signifi-cant, with a conservative estimate of more than $375 million yearly.[4] It is noteworthy that this figure does not include the broader financial impact experienced by families and caregivers as a result of lost time and productivity when caring for a sick child.

Recently there has been considerable interest in reevaluating best practices for the management of pediatric urolithiasis. Most pediatric patients with stone disease, similar to adults, need no surgical intervention. In fact, most will pass stones spontaneously, with or without adjunctive pharmacological therapy, and have no lasting sequelae.[5–7] However, surgical intervention is needed in approximately 20% to 25% of patients.[2,3]

Shock wave lithotripsy has been the historical gold standard for treatment of pediatric renal and ureteral calculi since the late 1980s and continues to be the foundation of current clinical practice guidelines.[8–10] However, advances in endoscopic technology have made the use of ureteroscopic lithotripsy a viable and increasingly common alternative treatment modality.[9,11,12] Despite substantial differences in invasiveness, cost and intraoperative/postoperative characteristics, studies directly comparing these 2 procedures in pediatric patients are lacking. Given current efforts to improve care quality and optimize cost management, a clearer understanding of the current state of pediatric endourological practice and the efficacy of available treatment modalities is needed. We performed a comparative effectiveness study to characterize differences in procedure frequency, postoperative readmissions and ER visits, and repeat treatment rates for pediatric patients (18 years or younger) with urolithiasis who underwent initial intervention with SWL or URS.

METHODS

Data Source

We analyzed state specific ambulatory surgery and services databases, emergency department databases and hospital inpatient databases from HCUP, sponsored by AHRQ. We limited our analysis to 2007 to 2010 for California, Florida, North Carolina and Utah, and 2008 to 2010 for New York due to data completeness and availability.

SASDs include annual, state specific, encounter level data for ambulatory surgeries and may also include various types of outpatient services such as observation stays, lithotripsy, radiation therapy, imaging, chemo-therapy, and labor and delivery. SEDDs comprise annual, encounter level databases cataloguing visits to hospital affiliated ERs that do not result in admissions. SIDs include annual, state specific, encounter level inpatient data and encompass about 97% of all U.S. hospital discharges. Using HCUP supplemental variables for revisit analysis, these state specific databases can be linked to track sequential visits for individual patients in each setting within a given timeframe. Per AHRQ requirements we restricted reporting of any events occurring in fewer than 15 patients.

Patient Selection

We identified pediatric patients (18 years or younger) with upper tract urolithiasis who underwent either SWL or URS as defined by ICD-9 (International Classification of Diseases, 9th revision, Clinical Modification) and CPT (Current Procedural Terminology) codes. Patients with neurogenic bladder, ureterocele, megaureter, posterior urethral valves, bladder exstrophy, kidney transplant or prune belly syndrome were excluded (supplementary Appendixes 1 and 2, http://jurology.com/).

Outcome Selection

The primary outcomes were subsequent inpatient admission or ER visit within 30 or 90 days of the initial procedure, and additional urolithiasis resolution procedure (SWL or URS) performed within 365 days of the initial procedure. All diagnoses were extracted, and genitourinary related diagnoses were selected to exclude subsequent encounters unlikely to be related to urolithiasis procedures using CCS codes from AHRQ. A cutoff of 365 days for additional urolithiasis procedures was chosen to better characterize the success of initial intervention.

Statistical Analysis

Predictor variables were a priori selected based on biological plausibility and/or demonstrated associations per the literature. Covariates included in the final model were age, gender, insurance payer (public vs private), median household income quartiles by zip code, Charlson comorbidity index, treatment year, treatment modality (SWL vs URS) and effect of center specific clustering. We fit an unadjusted logistic regression model to test for a trend in URS utilization.

Bivariate analyses were performed to compare patient demographics and hospital level characteristics of patient cohorts. We used chi-square, Fisher exact or Kruskal-Wallis test as appropriate based on data characteristics and distribution. We used a GEE model to account for the fact that patients within the same hospital tended to have similar outcomes. Given the structure of this data set, individual patients were unable to be tracked across multiple states. When patients were seen in 2 different states, they were considered unique at both encounters. The GEE model accounted for state and hospital level clustering since within the Nationwide Inpatient Sample each hospital identifier takes into account the state in which a patient is seen as well.

An alpha of 0.05 and 95% CIs were used as criteria for statistical significance. All analyses were performed using SAS®, version 9.4.

RESULTS

Demographics

We identified 1,087 SWL and 1,194 URS procedures (supplementary table, http://jurology.com/). Median patient age at surgery was 17 years across both groups, and females constituted the majority of the cohort. Compared to patients undergoing SWL, those who underwent URS were more likely to be female, to be privately insured and to have a ureteral rather than a renal stone. SWL was used more frequently than URS in California, while URS was used more commonly in New York, Florida, North Carolina and Utah.

Readmission, Unplanned ER Visits and Additional Urolithiasis Procedures

Table 1 details preprocedural stenting, 30 and 90-day GU related readmissions, ER visits and 365-day additional urolithiasis resolution procedures for patients undergoing SWL and URS. Within a 6-week window before initial treatment 4.2% of all patients had a ureteral stent placed with no significant difference between cohorts observed. Compared to URS patients, SWL patients underwent a greater number of additional urolithiasis resolution procedures within 12 months of initial treatment (18.8% vs 13.6%, p 0.0007). Repeat SWL was the most common =repeat procedure. URS was associated with a higher rate of 30-day GU related admissions (20.2% vs 12.5%, p <0.0001), 30-day GU ER readmissions (8.0% vs 5.2%, p = 0.0071) and 90-day GU ER visits (11.9% vs 9.3%, p = 0.0443). Bivariate and multivariate analyses using CCS determined readmissions are outlined in table 2. After adjusting for age, gender, procedure year, insurance type, Charlson comorbidity score, stone location, median family income and hospital/state clustering (with GEE) patients treated with URS remained significantly more likely to be readmitted (OR 2.10 at 30 days, p <0.0001; OR 1.41 at 90 days, p 0.01) and to visit the ER (OR 2.01 at 30 days, p <0.001; = OR 1.56 at 90 days, p = 0.01; overall OR 1.71, p = 0.01), and to require unplanned postoperative ER visits (OR 1.97 at 30 days, p <0.001; OR 1.59 at 90 days, p = 0.01) as determined by CCS codes.

DISCUSSION

Although previously studied in the adult population, direct comparisons of SWL and URS in the pediatric literature are rare. We sought to shed light on the current state of endourological practice in children using a retrospective analysis of large, well validated, linked state databases (SASDs, SEDDs and SIDs) to examine procedure frequency, 30 and 90-day postoperative ER readmissions, and repeat treatment rates for both procedures in a representative sample of states. Our analysis found URS more commonly used for initial treatment of pediatric upper tract calculi than SWL, with an increasing tendency in teenage patients. However, despite a slightly greater number of SWL patients undergoing additional urolithiasis resolution procedures within 12 months of treatment vis-à-vis those treated initially with URS, SWL patients did not have significantly greater odds of requiring repeat treatment for adequate disease resolution relative to those treated with URS. Children who underwent URS were more likely to be older, female and privately insured, and to have ureteral rather than renal stones compared to children treated with SWL. After adjusting for potential confounding variables GU related inpatient readmissions were 1.7 times more common with URS within 30 days of initial treatment. Similarly 30 and 90-day GU ER visits were 1.97 and 1.59 times more likely, respectively, in the URS cohort.

Originally described by Chaussy et al in 1980,[13] SWL was first used successfully in children by Newman et al in 1986.[14] SWL has since gained widespread use for initial management of renal and ureteral calculi smaller than 20 mm in children and adults. Lithotripter generated shock waves have been observed to have no demonstrable lasting effect on renal development or function, and the noninvasive nature of SWL combined with its relatively short recovery time and low cost made it a preferred option for patients and providers.[15–19] These characteristics also made SWL a good treatment option for children with stones that were difficult to pass, particularly compared to percutaneous nephrolithotomy or open ureterolithotomy, the primary treatment alternatives to SWL for much of the 1980s.[10,20,21] Indeed, even today SWL forms the cornerstone of pediatric endourological management in guidelines issued by the American Urological Association and the European Association of Urology.[8]

However, several studies in the adult and pediatric literature have revealed variable initial success rates for primary SWL treatment, ranging from 43% to 84%, with consensus estimates in approximately the 70% to 80% range.[10,22] Initial treatment with SWL may fail in children because of retained stone fragments, incomplete stone fragmentation or inappropriate use of SWL for overly large stones (greater than 20 mm), for cysteine or calcium oxa-late monohydrate stones or in patients with unfavorable anatomy preventing stone fragment passage.[20,23–25] The inability to directly visualize stone fragments retained in the collecting system intraoperatively is a major limitation of SWL and may partly explain the relatively high rate of additional stone procedures. Children who require additional rounds of SWL for stone resolution are at increased risk for complications associated with rehospitalization and sedation/anesthesia, and incur significant additional financial burden, which may negate SWL cost advantages.[11] Krambeck et al have raised concerns that SWL may inadvertently lead to other serious long-term health effects due to parenchymal damage to visceral organs within lithotripter blast paths.[26]

By comparison, URS was used infrequently in pediatric urology until recently. Ritchey et al in 1988 showed that URS could be successfully used in children.[27] However, limitations of ureteroscopic instrument technology prevented its widespread adoption.[11,12] The lack of flexible endoscopes of sufficiently small caliber to pass safely through a narrow pediatric urinary tract was a particular barrier that largely limited use of URS to adults and older adolescents. Rapid technological advances and greater comfort with ureteroscopy among providers made URS a viable alternative for treatment of most upper tract stones. Initial stone-free rates of 86% to 100% after primary treatment with URS have resulted in its use as first-line therapy for urolithiasis at many institutions, particularly as concerns regarding potential complications of URS (ie vesicoureteral reflux, ureteral stricture, ureteral perforation) have proved unfounded.[12,28,29] Significantly URS provides a key advantage over SWL in that it permits intraoperative examination of the collecting system.

The findings of our study must be viewed within the context of its design limitations. Our decision to use encounter data from linked state databases was driven by the fact that these data sets are among the largest, most well validated available. However, as with any retrospective administrative database, our analyses rely on accurate coding and database completeness.

Detailed patient level clinical factors, such as stone size, location, number and distribution, patient body mass index and underlying metabolic abnormalities, were not available in the selected databases. Thus, the result may be affected by the preoperative indication. For example patients with bilateral disease may undergo a staged procedure rather than repeat treatment. However, with current controversies and various treatment patterns a clear selection pattern or bias between the 2 treatment modalities has not been established.[30] Therefore, we chose to present these data to reflect the real-life data in hopes of piquing more interest in future prospective trials investigating this subject.

Additionally although the accuracy of SASDs, SEDDs and SIDs is relatively high for administrative databases, we cannot exclude the possibility of miscoding bias. To minimize this limitation, these databases are routinely and rigorously monitored by HCUP for coding accuracy and insofar as possible represent a reasonably reliable snapshot of the respective cohorts.

The decision to use only a small subset of available states was driven primarily by the depth of data capture by participating agencies in those states, particularly the ability to track individual patients with multiple encounters through time. Due to regional variations in health care practices, our reported results may not be generalizable to encounters from states not included in the sample pool. However, the states chosen represent a diverse sample of geographic regions and demographic and socioeconomic composition, and together can be considered a reasonably accurate proxy for the country as a whole. In addition, certain states opted to discontinue individual patient tracking after 2010, limiting our ability to comment definitively on usage trends for SWL and URS in the years since then. However, given that numerous other studies have continued to support the notion that URS adoption as the primary interventional treatment for pediatric urolithiasis is increasing, we believe that the trends reported in our study present an accurate picture of current practice patterns.

Most significantly the dearth of highly accurate, current and large outpatient data sets in pediatrics meant we were unable to include an analysis of outpatient encounters not captured in SASDs, notably in patients who underwent minor procedures or treatments performed postoperatively by their primary care physician, urologist or urgent care center. Although we believe that the number of patients not included in our cohort from these encounters is relatively small, we cannot exclude the possibility that such data may alter our understanding of repeat treatment and revisit rates. The lack of such data sets for pediatric subspecialties continues to be a concern.

Our analysis adds to the growing body of literature supporting the rapid appropriation of URS by pediatric urologists for primary treatment of urolithiasis. Given these findings, we believe that a robust discussion of possible revisions to current clinical practice guidelines may be warranted. Although URS has begun to outpace the use of SWL for initial stone management in children, it is important to remember that interventional choice is undoubtedly multifactorial and patient/setting specific. Future investigations more closely examining these factors as they pertain to urolithiasis treatment choices are warranted.

CONCLUSIONS

Pediatric patients with urolithiasis were more likely to undergo URS than SWL during a 4-year period across 5 states. More children undergoing SWL underwent additional procedures. However, URS was associated with an increased likelihood of subsequent inpatient admissions and ER visits.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations and Acronyms

AHRQ	Agency for Healthcare Research and Quality
CCS	Clinical Classifications Software
ER	emergency room
GEE	generalized estimating equation
GU	genitourinary
HCUP	Healthcare Cost and Utilization Project
SASD	state specific ambulatory surgery and services database
SEDD	state specific emergency department database
SID	state specific hospital inpatient database
SWL	shock wave lithotripsy
URS	ureteroscopy

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Table 1.

Postoperative outcomes by surgery type

	SWL	URS	Totals	p Value
No. prior stent within 6 wks of procedure/total No. (%)	41/1,087 (3.8)	54/1,194 (4.5)	95/2,281 (4.2)	0.3700 (chi-square test)
No. CCS GU readmissions/total No. (%):				
30-Day	136/1,087 (12.5)	241/1,194 (20.2)	377/2,281 (16.5)	<0.0001 (chi-square test)
90-Day	260/1,087 (23.9)	307/1,194 (25.7)	567/2,281 (24.9)	0.3224 (chi-square test)
No. CCS GU ER visits/total No. (%):				
30-Day	56/1,087 (5.2)	95/1,194 (8.0)	151/2,281 (6.6)	0.0071 (chi-square test)
90-Day	101/1,087 (9.3)	142/1,194 (11.9)	243/2,281 (10.7)	0.0443 (chi-square test)
No. 365-day additional procedures/total No. (%):	204/1,087 (18.8)	162/1,194 (13.6)	366/2,281 (16.0)	0.0007 (chi-square test)
SWL	124/1,087 (11.4)	44/1,194 (3.7)	168/2,281 (7.4)	<0.0001 (chi-square test)
URS	75/1,087 (6.9)	93/1,194 (7.8)	168/2,281 (7.4)	0.4168 (chi-square test)
Stent	104/1,087 (9.6)	112/1,194 (9.4)	216/2,281 (9.5)	0.8787 (chi-square test)
No. 365-day readmissions/total No. (%)				0.0010 (Fisher exact test)
0	883/1,087 (81.2)	1,032/1,194 (86.4)	1,915/2,281 (84.0)	
1	105/1,087 (9.7)	73/1,194 (6.1)	178/2,281 (7.8)	
More than 1	99/1,087 (9.1)	89/1,194 (7.5)	188/2,281 (8.2)	

Table 2.

Bivariate and multivariate analysis of association of postoperative outcomes and surgery type (SWL as reference) using CCS codes

Outcomes	Unadjusted OR (95% CI)	Adjusted OR (95% CI)*	p Value*
30-Day GU readmissions (yes/no)	1.77 (1.41–2.22)	2.10 (1.55–2.83)	<0.0001
90-Day GU readmissions (yes/no)	1.10 (0.91–1.33)	1.41 (1.11–1.79)	<0.01
30-Day GU ER visits (yes/no)	1.59 (1.13–2.24)	2.01 (1.35–3.01)	<0.001
90-Day GU ER visits (yes/no)	1.32 (1.01–1.73)	1.56 (1.12–2.17)	<0.01
365-Day additional procedure	0.68 (0.54–0.85)	0.90 (0.69–1.17)	0.44

*Adjusted for age, gender, year, insurance, comorbidity score, stone location, hospital clustering and median salary.