Comparison of Retrograde Intrarenal Surgery and Mini-percutaneous Nephrolithotomy in Children With Moderate-size Kidney Stones: Results of Multi-institutional Analysis

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OBJECTIVE To compare the outcomes of miniaturized percutaneous nephrolithotomy (mini-perc) and retrograde intrarenal surgery (RIRS) in children for 10- to 30-mm renal calculi by evaluating operative data, stone-free rates, and associated complications.

METHODS The records of 201 pediatric patients who underwent mini-perc (n = 106) or RIRS (n = 95) for intrarenal stones of 10- to 30-mm size were reviewed retrospectively. The χ^2 test was applied to compare the success rates, postoperative complications, and blood transfusion rates, and the Mann-Whitney *U* test was used to compare the means of hospital stay, fluoroscopy, and operative time for mini-perc and RIRS.

RESULTS The stone-free rate was 84.2% for the RIRS group and 85.8% for the mini-perc group after a single procedure (P = .745). These percentages increased to 92.6% and 94.3% with adjunctive therapies for RIRS and mini-perc, respectively. Minor complications classified as Clavien I or II occurred in 17% and 8.4% in mini-perc and RIRS, respectively. No major complications (Clavien III-V) occurred in either group. Overall complication rates in mini-perc were higher, but the differences were not statistically significant (P = .07). However, 7 patients in the mini-perc group received blood transfusions, whereas none of the children in the RIRS group were transfused (P = .015). The mean hospital stay, fluoroscopy, and operation times were significantly longer in the mini-perc group.

CONCLUSION This study demonstrates that RIRS is an effective alternative to mini-perc in pediatric patients with intermediate-sized renal stones. Operative time, radiation exposure, hospital stay, and morbidities of percutaneous nephrolithotomy (PNL) can be significantly reduced with the RIRS technique. UROLOGY 80: 519–523, 2012. © 2012 Elsevier Inc.

The management of upper urinary stone disease in children has changed dramatically in the last decade with the technological advancement and miniaturization of instruments.[1-6] Today, shock wave lithotripsy (SWL) is one of the main modalities for treating pediatric renal stones, and the selected cases can be managed effectively and safely using SWL. However, the long-term effects of shock waves on developing kidneys are not clear and many studies have shown that the success rate of SWL decreases significantly with increasing stone size and multiplicity.[6-8] The requirement for multiple sessions and the need for general anesthesia in children are other drawbacks of this procedure.[9]

Percutaneous nephrolithotomy (PNL) has significantly higher stone-free rates and lower requirements for ancillary procedures compared with SWL.[1-7,10] This trend is further promoted by the introduction of miniaturized PNL (mini-perc), which is postulated to be less invasive compared with standard PNL because of the miniaturized instruments.[11] However, PNL may present problems in children, despite modifications, such as the "mini-perc," because of small size and mobility of the pediatric kidney, friable renal parenchyma, and the small size of the collecting system. Today PNL is typically reserved for larger stone burden and treatment failures of SWL because of its more invasive nature.[9-11]

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A viable alternative in these patients is retrograde intrarenal surgery (RIRS), which may be performed at single or multiple stages depending on stone burden and location.[12] In a growing number of centers, including ours, RIRS is now being performed in cases that previously would have been managed with SWL or PNL. However, no previous study has examined the PNL and RIRS specifically in this cohort of patients and compared the clinical outcomes of these approaches. In this study, we examined our experience with mini-perc and RIRS for 1- to 3-cm renal stones in children by evaluating stone-free rates and associated complications.

MATERIAL AND METHODS

Patients

We performed a retrospective analysis of 201 evaluable pediatric patients, aged 17 years or younger, who underwent mini-perc (n = 106) or RIRS (n = 95) for intrarenal stones of 10- to 30-mm size between January 2008 and November 2011 in 5 referral hospitals in Turkey. Patient selection for either treatment was done individually and included other treatments that failed, renal pelvicaliceal anatomy, and patient or parent preference. All surgeons did both types of procedures. Patients with bleeding diathesis, abnormal renal anatomy, and musculoskeletal deformities were excluded from the study.

Patient assessment included medical history, physical examination, urinalysis, urine culture, complete blood count, serum biochemistry, coagulation tests, intravenous urography (IVU), and/or computerized tomography (CT). Positive urine cultures were adequately treated with appropriate antibiotics and all patients had a negative urine culture before surgery. Stone size was determined by measuring the longest axis on preoperative radiologic investigation; in cases of multiple calculi, stone size was defined as the sum of the longest axis of each stone.

Mini-Perc Technique

All procedures were performed under general anesthesia, with the patient in the prone position, after retrograde catheterization with a 4-Fr or 6-Fr ureteral catheter. Percutaneous access was achieved by a urologist under fluoroscopic guidance using an 18-gauge needle. Tract dilation was accomplished using Amplatz dilators of up to 12-22 Fr. Fragmentation and stone removal were accomplished in all patients using holmium, pneumatic, or ultrasound energy and retrieval graspers through rigid 11-, 15.9-, 17-, and 22-Fr nephroscopes. A holmium laser and nitinol basket catheter were used through a flexible nephroscope for migrated stone fragments that were unreachable with the rigid instruments. The operations were completed when residual fragments were not detected on fluoroscopic imaging control. After completion of PNL, a nephrostomy tube was placed, which was routinely removed on postoperative days 1-2, and the patient was discharged to home the next day.

RIRS Technique

Under general anesthesia, the children were placed in the lithotomy position on an endoscopy table with fluoroscopic imaging capability. Cystoscopy or rigid ureteroscopy was performed to place a hydrophilic guidewire to the renal pelvis under fluoroscopic guidance. After passing a 0.035/0.038-inch safety guidewire into the renal pelvis, a ureteral access sheath was placed (9.5/11.5 Fr, 35 cm). The use of the ureteral access sheath was determined primarily by surgeon preference for younger children and those with a large stone burden, which indicated the possibility of multiple passages of the ureteroscope. Ureteral orifice dilation was performed in selected cases with balloon dilators when the rigid/flexible ureteroscope could not be advanced easily. A manual irrigation pump system was used to hydrodilate the ureter during ureteroscopy. There were no cases in which the stone was removed without fragmentation. The stones were fragmented with a holmium:YAG laser until they were deemed small enough to pass spontaneously. Basket extraction of residual fragments was not routinely performed; however, some residual fragments were removed by tipless nitinol baskets for stone analysis. When feasible, lower pole stones were relocated to a more favorable location in the upper calix by basketing to allow for better visualization during lithotripsy. A double-J stent was placed at the end of the procedure based on surgeon decision and was removed using brief anesthesia approximately 10-14 days (range 7-28) postoperatively.

Data Analysis

Initial postoperative stone-free rates were determined the day after surgery with a radiographic study (kidney-ureter-bladder). Afterward, final stone-free rates were determined in an outpatient clinic setting at 1-month postoperatively with low-dose spiral CT or combination of kidney-ureter-bladder radiograph and sonography. The procedure was considered successful if the patient was stone free.

All statistical analyses were performed using SPSS 11.5 (IBM, Armonk, NY). The χ^2 test was applied to compare the success rates, postoperative complications, and blood transfusion rates, and the Mann-Whitney U test was used to compare the hospital stay, fluoroscopy, and operative time for mini-perc and RIRS. Although the categorical variables are presented by frequency (percent), continuous variables are presented by mean ± standard deviations (median [minimum-maximum]). Statistical significance was defined as $P < .05$.

RESULTS

Patient and Stone Characteristics

A retrospective review identified stones in 201 pediatric patients, including 109 males (54.2%) and 92 females (45.8%). The mean age was 9.5 ± 5.09 years (range 9 months–17 years) and the stone was on right side in 92 patients (45.8%) and on the left side in 109 patients (54.2%). There were no differences between the 2 groups in age, gender, and stone laterality. However, the mean stone size was 23.7 ± 4.4 mm (25 [range 10-30]) in the mini-perc group and 14.3 ± 3.8 mm (14 [10-30]) in the RIRS group. As delineated in Table 1, mean stone size was significantly larger in patients who were treated with mini-perc ($P < .001$). Stone composition was available in 177 patients (88%), and calcium oxalate was the most frequent composition in both groups. In mini-perc cases, there were 63 calcium (40 calcium oxalate, 4 calcium phosphate, 19 mixed); 19 cystine; 8 struvite; and 4 uric acid stones. In RIRS cases, there were 66 calcium (40 calcium oxalate, 2 calcium phosphate, 24 mixed); 8 struvite; 5 cystine; and 4 uric acid stones. Table 1 lists patient demographics and stone characteristics.

Table 1. Demographic data and stone characteristics

	Mini-perc Group	RIRS Group	*P* Value*
No. patients (%)	106 (52.7%)	95 (47.3%)	—
Mean age ± SD, years (range)	9.6 ± 4.9 (10 [1-17])	9.3 ± 5.2 (9 [1-17])	.708
Male/female	56/50	53/42	.674
Mean stone size ± SD, mm (range)	23.7 ± 4.42 (25 [10-30])	14.3 ± 3.81 [14 (10-30)]	<.01
Stone location			
Pelvis	36 (34%)	29 (30.5%)	
Lower pole	19 (17.9%)	29 (30.5%)	
Upper/middle pole	12 (11.3%)	28 (29.4%)	
Multicaliceal	39 (36.8%)	9 (9.4%)	
Stone composition			
Ca oxalate/phosphate or mixed	63 (59.5%)	66 (69.5%)	
Struvite	8 (7.5%)	8 (8.4%)	
Uric acid	4 (3.8%)	4 (4.2%)	
Cystine	19 (17.9%)	5 (5.3%)	
Unknown	12 (11.3%)	12 (12.6%)	

* Significant at 0.05 level.

Table 2. Comparison of operative and postoperative data

	Mini-perc Group	RIRS Group	*P* Value
Mean fluoroscopy time ± SD (sec)	113.7 ± 36.6 [110 (0-255)]	33.2 ± 14.6 [30 (15-90)]	<.001*
Mean operative time ± SD (min)	76.3 ± 21.2 [75 (30-165)]	42.1 ± 15.3 [40 (15-90)]	<.001*
Mean hospitalization time ± SD (day)	3.1 ± 1.2 [3 (1-7)]	1.7 ± 0.6 [2 (1-5)]	<.001*
Initial stone-free rate	91 (85.8%)	80 (84.2%)	.745
Stones ≥20 mm	78/93 (83.9%)	4/8 (50%)	
Stones <20 mm	13/13 (100%)	76/87 (87.3%)	
Final stone-free rate	100 (94.3%)	88 (92.6%)	
Minor (Clavien I-II) complications	18 (17%)	8 (8.4%)	.071
Major (Clavien III-V) complications	—	—	
Blood transfusion rate	7 (6.6%)	—	.015*

* Significant at 0.05 level.

Operative and Postoperative Findings

The mean operative time for the RIRS and mini-perc groups was 42.1 ± 15.3 minutes (range 15-90) and 76.3 ± 21.2 minutes (range 30-165), respectively (P <.001). The mean fluoroscopy screening time was 113.7 ± 36.6 seconds in the mini-perc group and 33.2 ± 14.6 seconds in the RIRS group (P <.001). The stone-free rate was 84.2% for the RIRS group and 85.8% for the mini-perc group after a single procedure (P = .745). In the RIRS group, the stone-free rates for stones <20 mm were 87.3% and 50% for stones ≥20 mm. In the mini-perc group, the stone-free rates for stones <20 mm was 100% and 83.9% for stones ≥20 mm. In the mini-perc group, 5 patients had insignificant fragments and were followed without any intervention; 10 required additional procedure (SWL in 6, second mini-perc in 4) and 9 of these were completely stone free, resulting in an overall success rate of 94.3%. In the RIRS group, the success rate increased to 92.6% after a second intervention (SWL in 4, second RIRS in 4). Seven patients had asymptomatic residual fragments <7 mm in the lower pole of the kidney, and these patients were followed with urinary ultrasonography.

In the RIRS group, dilation of the ureteral orifice was required in 18 cases (18.9%), and ureteral access sheaths were placed in 60 patients (63.1%). A double-J stent was placed in 65 patients (68.4%) at the conclusion of the RIRS procedure and was removed under brief anesthesia approximately 10-14 days postoperatively. Average hospital stay in the RIRS group was 1.7 ± 0.65 days, which was significantly shorter than that for the mini-perc group (3.1 ± 1.2 days) (P <.001). Minor complications as classified by Clavien I or II occurred in 17% and 8.4% in the mini-perc and RIRS groups, respectively. No major complications (Clavien III-V) occurred in both groups. Overall complication rates in the mini-perc group were higher but the differences were not statistically significant (P = .07). Seven patients in the mini-perc group received blood transfusions, whereas none of the children in RIRS group were transfused (P = .015). In the mini-perc group, 5 patients (8.7%) in the 22-Fr access group and 2 (5.2%) in the 18-Fr access group required blood transfusions, whereas none of the patients in the 12-Fr access group was transfused. Intraoperative and postoperative findings of patients are summarized in Table 2.

COMMENT

Stone disease is not common in children but is often associated with anatomic and metabolic abnormalities or infectious diseases, and the risk of recurrence is high.[13] These factors make minimally invasive procedures more important in this age group.[1,3] The SWL is a well-established treatment method and most pediatric stone

diseases can be managed effectively and safely with this technique. However, there are some stones that do not respond to SWL, and these can be managed by new minimally invasive techniques, such as mini-perc and RIRS. However, the relatively rare incidence of stone disease in children results in a lack of information regarding the safety and efficacy of these techniques. Furthermore, no previous study has specifically examined the mini-perc and RIRS in this cohort of patients and compared the clinical outcomes of these approaches.

PNL has become a standard surgical choice for large pediatric stone disease since it was first reported in 1985 by Woodside et al.[14] The first pediatric PNL series were performed with adult instruments with similar success but higher complication and transfusion rates.[15,16] In the adult standard technique, the kidney can be accessed through 24- to 30-Fr Amplatz sheaths and large tract dilation theoretically causes more parenchymal and, inadvertently, vascular injury, especially in the relatively smaller kidney. From the same perspective, Jackman et al described the "mini-perc" technique with a 7-Fr rigid cystoscope over an 11-Fr vascular access sheath.[17] Since then, endourologists have been encouraged to use smaller instruments in pediatric patients. Desai et al reported their experience of PNL for pediatric renal calculi in 56 patients, and complete clearance was achieved with PNL monotherapy in 90%.[18] They showed that intraoperative hemorrhage during PNL is related to the caliber and the number of tracts, and they recommended that dilation should be kept below 22 F. In our study, 7 patients (%6.6) required blood transfusion. Five patients (8.7%) in the 22-Fr access group and 2 (5.2%) in the 18-Fr access group required blood transfusions, whereas none of the patients in the 12-Fr access group was transfused. In the pediatric PNL literature, the transfusion rate was reported to be between 0.4% and 23.9% and was associated with stone burden, sheath size, number of tracts, dilation technique, and operative time.[2,3,9-11,19] The balloon dilation technique is less traumatic and results in less bleeding and scar formation because the inflated balloon supplies constant pressure, rather than a shearing force, on the access tract. However we have only 30-Fr balloon dilators in our country and we can use this size only in adults. Davidoff and Bellman reported a significantly lower blood transfusion rate in patients whose tracts were dilated using the balloon compared with those in whom Amplatz fascial dilators were used.[19] In their series, 25 of 100 (25%) patients undergoing percutaneous renal Amplatz dilation required a blood transfusion compared with only 5 of 50 (10%) undergoing balloon dilation.

The stone-free rate after mini-perc in this present series was similar to previous studies (75-100%), with success rates of approximately 85.9%.[14-21] Although stone-free rates are >75% after a single PNL in children, complications, including urosepsis, bleeding requiring transfusion, renal pelvis perforation, and injury to adjacent organs, are not uncommon.[14-18] As we classify our complications regarding the modified Clavien system (Appendix), we observed only grade I and II complications in both of the groups and all complications were managed successfully without issue.[22] We found that the stone-free rate and complications were higher with the percutaneous approach, although the difference was not statistically significant. Stone-free rate after a single treatment with RIRS was excellent and was comparable with the results of mini-perc for stones smaller than 2 cm. Although mini-perc is considered a more invasive procedure, it remains the first-line therapy for stones 2-3 cm in size because of higher stone-free rates.

In recent years, several authors reported feasibility of retrograde stone removal even for larger stones, which are usually treated with PNL.[23,24] However a few centers have reported their experience of flexible ureteroscopy in pediatric patients, and all published studies to date have included ureteral stones, and most of those reports include a significant number of older adolescents. In 2005, Tan et al described 23 children with urolithiasis treated with ureteroscopy, with a success rate of 95%. However, only 2 calculi were present in the kidney.[25] In 2007, Cannon et al reported a 76% stone-free rate and no major complications in 21 children with lower pole renal calculi.[26] They observed a similar stone-free rate in their series of prepubertal and postpubertal patients with intrarenal calculi. Smaldone et al published the largest series of pediatric ureteroscopies in 100 patients as old as 20 years who had urolithiasis.[27] That study, which included 33 patients with renal stones, showed an overall 91% stone-free rate but the results for renal stones were not mentioned separately. In 2011, Unsal and Resorlu reported their RIRS series in children 7 years or younger with an overall complication rate of 5.8% and success rate of 88% after a single treatment.[1]

In the present study, the mean duration of fluoroscopy and operative time were found to be longer in the mini-perc group relative to the RIRS. Creation of percutaneous renal access under fluoroscopic guidance is the most important reason for the longer fluoroscopy and operative time. The long operative time in mini-perc patients can be related to relatively high stone burden in this study. Also, hospital stay was longer in the mini-perc group. One of the most important reasons for this delay is nephrostomy tube placement for better drainage. Operative time, radiation exposure, hospital stay, and morbidities of PNL can be significantly reduced with RIRS technique.

There are several limitations in our study. The first is that the study is retrospective in nature. Second, analgesic and postoperative pain scores were not evaluated. Third, different imaging modalities were used to assess the residual stone burden. This limitation arose from the multicentric and retrospective nature of the study. Finally, the most important limitation of the present study is that there was a significant difference in stone size

between the 2 groups. Therefore, our findings must be confirmed by further prospective randomized studies. Despite these shortcomings, this is an important study, because there are no data in the literature regarding the relative merits of mini-perc and RIRS in a contemporary cohort of patients.

CONCLUSIONS

The data here suggest that mini-perc and RIRS are highly effective methods of treatment for children with stones up to 2 cm. Although PNL is effective, its biggest drawback is its invasiveness and the possibility of some blood loss. Hospital stay, radiation exposure, and morbidities of mini-perc can be reduced significantly with RIRS technique. By contrast, mini-perc continues to be the best-choice treatment modality for stones 2-3 cm in size because of its more effective nature. Today, patients and their parents should be informed about the available treatment options and their efficacy and safety.

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APPENDIX

CLAVIEN CLASSIFICATION OF SURGICAL COMPLICATIONS:

Grade I, any deviation from the normal postoperative course without the need for pharmacologic treatment or surgical, endoscopic, and radiological interventions

Grade II, requiring pharmacologic treatment with drug other than such allowed for grade I complications

Grade III, Requiring surgical, endoscopic, or radiological intervention.

- **Grade IIIa**, intervention not under general anesthesia
- **Grade IIIb**, intervention under general anesthesia

Grade IV, life-threatening complication

- **Grade IVa**, single organ dysfunction
- **Grade IVb**, multiorgan dysfunction

Grade V, death of a patient