

## Retrograde intrarenal surgery in pediatric patients

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### Abstract

Urinary tract stone disease is seen at a level of 1%-2% in childhood (< 18 years). In recent years, however, there has been a marked increase in pediatric stone disease, particularly in adolescence. A carbohydrate- and salt-heavy diet and a more sedentary lifestyle are implicated in this increase. Although stone disease is rare in childhood, its presence is frequently associated with metabolic or anatomical disorders or infectious conditions, for which reason there is a high possibility of post-therapeutic recurrence. Factors such as a high possibility of recurrence and increasing incidence further enhance the importance of minimally invasive therapeutic options in children, with their expectations of a long life. In children in whom active stone removal is decided on, the way to achieve the highest level of success with the least morbidity is to select the most appropriate treatment modality. Thanks to today's advanced technology, renal stones that were once treated only by surgery can now be treated with minimally in-

vasive techniques, from invasion of the urinary system in an antegrade (percutaneous nephrolithotomy) or retrograde (retrograde intrarenal surgery) manner or shock wave lithotripsy to laparoscopic stone surgery. This compilation study examined studies involving the RIRS procedure, the latest minimally invasive technique, in children and compared the results of those studies with those from other techniques.

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**Key words:** Percutaneous nephrolithotomy; Pediatric; Renal stone; Retrograde intrarenal surgery; Shockwave lithotripsy

**Core tip:** In the last two decades, technological advancement of instruments have changed the treatment options of renal stone disease. Today retrograde intrarenal surgery may represent an alternative treatment modality to shock wave lithotripsy and percutaneous nephrolithotomy, with acceptable efficacy and low morbidity in pediatric patients.

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### RETROGRADE INTRARENAL SURGERY IN CHILDREN

Treatment of urinary stone disease in pediatric patients is a challenging problem<sup>[1-5]</sup>. Although the indications employed in treatment selection in children are regarded as the same as those for adults, children respond particularly well to shock wave lithotripsy (SWL)<sup>[6]</sup>. The fact that developing kidney tissue transmits shock waves better and that spontaneous passage is comparatively

easier in children than in adults both play a role in this rapid response. SWL, which began being applied in the 1980s with the principle of the use of high-energy shock waves, represents a milestone in the treatment of stone disease in children<sup>[7]</sup>.

Gofrit *et al*<sup>[8]</sup> compared the results of pediatric and adult patients administered SWL for renal stones larger than 10 mm, and reported stone-free status levels of 95% in children and 78.9% in adults. Similar results were obtained from many subsequent studies. In a recent randomized prospective study Mokhles *et al*<sup>[9]</sup> compared the outcome of retrograde intrarenal surgery (RIRS) and SWL for stones 10 to 20 mm in preschool age children. They found that the overall stone-free rate was 93% and 96% for SWL and RIRS groups, respectively. SWL is therefore recommended as the first treatment option in children with stones of up to 20 mm (approximately 300 mm<sup>2</sup>) in modern guidelines<sup>[10]</sup>. However, the fact that the procedure usually requires general anesthesia in children, the need for general anesthesia in repeat sessions, concerns over the possibility of long-term renal scarring, hypercalciuria, hypertension or chronic renal insufficiency and some stones (cysteine stones, *etc.*) not responding to the technique represent concerns over its use in children<sup>[10,11]</sup>.

Technological advances in recent years has permitted the miniaturization of endoscopic devices, as a result of which percutaneous nephrolithotomy (PNL) has become the first treatment option for stones larger than 2 cm in children<sup>[11]</sup>. Although the procedure was initially performed with adult-type devices, Jackman *et al*<sup>[12]</sup> described a “mini-perc” technique using a 7 Fr rigid cystoscope and 11 Fr vascular access. They emphasized that a smaller tract will lead to less tissue and nephron injury and that this is more significant in pediatric patients with small and delicate kidneys, citing the example of a 24 Fr access sheath used in an infant being equivalent to 72 Fr in an adult.

Desai *et al*<sup>[13]</sup> reported that intraoperative hemorrhage occurring during PNL is related to the number and diameter of tracts, for which reason tract diameter should not exceed 22 Fr. In the majority of subsequent pediatric PNL series, the risk of intraoperative complications has been shown to decrease with use of small-size instruments<sup>[11,14]</sup>. Indeed, new PNL modifications aimed at reducing complication levels still further, such as tubeless PNL, ultramini-PNL and micro-perc, have been described<sup>[15-17]</sup>. However, despite all these modifications and high success rates, major complications such as neighboring organ injury, severe hemorrhage and urosepsis are still reported at levels of up to 10%, and the debate over whether the procedure is truly non-invasive continues<sup>[18,19]</sup>.

RIRS is a comparatively new concept in pediatric patients. Before embarking on the details of this method in children, it will be useful to briefly review the stages by which it arrived at its present-day position. Use of this technique for treating renal stones was first described in

1983, by Huffman *et al*<sup>[20]</sup>, when a large stone located in the renal pelvis was broken with the help of a ureteroscope with a rigid rod-lens structure and an ultrasonic lithotripter. Although the authors maintain that stones in the upper ureter and renal pelvis can be effectively and safely treated using small caliber rigid devices, the technique as it stands has not achieved popularity, due to its low success rate and high level of complications. Retrograde treatment of renal stones has been able to enter into widespread use only with the development years later of flexible ureteroscopes (f-URS) possessing fiberoptic technology and retrieval instruments with a nitinol structure and the simultaneous entry into use of Ho:YAG laser in intracorporeal lithotripsy<sup>[21]</sup>.

Following the first description of the pediatric ureteroscopy (URS) by Ritchey *et al*<sup>[22]</sup> in 1998, the development of URS decelerated due to concerns over existing instruments not being of suitable sizes for children, the inadequacy of optic imaging systems and development of complications post-URS in child patients, such as ischemia, injury, perforation, stricture and vesicoureteral reflux, and this delayed the use of RIRS in this patient population<sup>[22,23]</sup>. However, the development in subsequent years of more resistant and finer (< 8 Fr) ureteroscopes and auxiliary nitinol instruments, the improvement of optic system quality, the entry into use of Ho:YAG laser and, parallel, to all these technological advances, an increase in surgeon experience with flexible URS led to the technique also starting to be used in child patients.

The first wide series on the subject of pediatric RIRS was published by Cannon *et al*<sup>[24]</sup> in 2007. Twenty-one child patients (13 girls, 8 boys) administered RIRS due to lower pole renal stone and with a mean stone size of 12 mm were included in that study. After a mean 11 mo of follow-up, stone-free status was achieved at a level of 76%, and no intra- or postoperative complications were reported in any patient. Passive dilatation was applied using preoperative stent in 38% of patients, while a ureteral access sheath was used in 43% (Table 1). However, the upper age limit was set at 20 (mean 15.1) in that publication reporting a pediatric series and a great many cases were postpubertal (67%) patients.

A 100-case series was published by Smaldone *et al*<sup>[25]</sup> in that same year. Although 37% of the stones in that series were intrarenal (renal pelvis 6%, upper pole 10% and lower pole 17%). Mean stone size was 8.3 mm and mean patient age was 13.2 years, with 49% of cases being prepubertal children. Passive dilatation was applied in 54% of cases, ureteral active dilatation with a coaxial dilator to 70% and ureteral access sheath to 24%. Stone-free status was achieved in 91% of patients, while ureteral perforation developed in 5 and ureteral reimplantation was required due to stricture in the late period in one. However, no correlation was reported in that study between the complications that developed and use of ureteral access sheath or ureteral dilation.

In a study from 2008, Tanaka *et al*<sup>[26]</sup> published the

**Table 1** Outcomes of pediatric retrograde intrarenal surgery procedures in published series

Ref.	Patient No.	Mean age, yr	Mean stone size (mm)	Passive dilatation	Active dilatation	Ureteral access sheath	Success	Complications
Cannon <i>et al</i> <sup>[24]</sup>	21	15.2 (1-20)	12 (± 5.9)	38%	81%	43%	76%	0%
Smaldone <i>et al</i> <sup>[25]</sup>	100	13.2 (± 5.4)	8.3 (± 5.3)	54%	70%	24%	91%	Ureteral stricture (1%) Ureteral perforation (5%)
Tanaka <i>et al</i> <sup>[26]</sup>	50	7.9 (1.2-13)	8 (1-16)	56%	35%	48%	58%	0%
Kim <i>et al</i> <sup>[23]</sup>	167	5.2 (1-18)	6.1 (3-24)	57%	-	?	99%	0%
Unsal <i>et al</i> <sup>[27]</sup>	16	4.2 (0-7)	11.5 (8-17)	37.50%	29.40%	17.60%	88%	Ureteral perforation ( <i>n</i> = 1)
Erkut <i>et al</i> <sup>[28]</sup>	65	4.3 (0-7)	14 (7-30)	-	100%	100%	93%	27% complication rate
Abu Ghazaleh <i>et al</i> <sup>[29]</sup>	56	8.2 (6-14)	12 (9-15)	100%	-	-	100%	Urinary infection ( <i>n</i> = 3) Hematuria ( <i>n</i> = 1)
Resorlu <i>et al</i> <sup>[30]</sup>	95	9.4 (0-17)	18 (10-30)	?	18.90%	63.10%	85%	8.4 complications

results from 50 pediatric patients with a mean age of 7.9 (1.2-13.6 years) and receiving RIRS due to renal stone. Mean stone size was 8 mm (1-16) mm; 58% of cases remained stone-free at long-term follow-up with a single procedure, while an additional procedure was required in 36%. Success rate was correlated with stone size ( $P = 0.005$ ), while additional procedure requirement was correlated with both stone dimension ( $P = 0.002$ ) and patient age ( $P = 0.04$ ). However, the text refers to procedures being performed for stones as small as 1 mm.

Kim *et al*<sup>[23]</sup> reported the experience with flexible URS of the Philadelphia Children's Hospital, announcing the results of 170 procedures performed on 167 pediatric patients with a mean age of 62.4 mo (range, 3-218). Mean stone dimension was 6.1 mm (range, 3-24), with stones in 60% of cases being intrarenally located (28% upper ureter stone, 12% upper ureter stone). Access to the ureter could not be established in 57% of patients, for which reason a stent was inserted and left to passive dilatation. Ureteral access sheath was only used in cases with a heavy stone burden or receiving passive dilatation, although no level of use was cited. Following surgery lasting a mean 107 min (range, 72-196), 100% of patients with stones smaller than 10 mm achieved stone-free status, and 97% of those with stones larger than 10 mm. No intra- or postoperative complications were reported in this series.

Unsal *et al*<sup>[27]</sup> examined the reliability of this procedure in pre-school children, evaluating 16 child patients with a mean age of 4.2 years (range, 10 mo-7 years). Mean stone dimension was 11.5 mm (range, 8-17); 37.5% of patients received double-j stent (passive dilatation), active dilatation was performed on 29.4%, and ureteral access sheath was used in 17.6%. One hundred percent of patients with stones smaller than 10 mm and 81% of those with larger stones achieved stone-free status. Ureteral perforation developed during ureteral dilatation in one case. That study showed that RIRS can successfully be used in infants aged under 1 year, describing

the youngest (10 mo) case treated using the procedure in the literature. Subsequently, Erkurt *et al*<sup>[28]</sup> showed with a wider case series that the procedure can be safely used in pre-school age children. In that study, a ureteral access sheath was used in each case, and complication rates of 27% and stone-free status of 93% were reported.

In a study evaluating the efficacy of RIRS in prepubertal children Abu Ghazaleh *et al*<sup>[29]</sup> reported the results from 56 children (age 6-14) with stones less than 15 mm in size. Pre-procedural passive dilatation was performed in all cases, and electrohydraulic lithotripsy was used for stone breaking. At the end of 34-mo follow up, 100% stone-free status was reported and no intraoperative complication developed, although urinary infection was reported in 3 patients in the postoperative period and macroscopic hematuria in one. The use of a lithotripsy technique that has been abandoned due to high complication levels, each patient being subjected twice to anesthesia with the application of passive dilatation and stones inside the renal pelvis being broken with rigid URS represent question marks in that study, despite such high success rates.

In a multi-center comparative analysis (Table 2), Resorlu *et al*<sup>[30]</sup> compared the outcomes of patients with renal stones 10-30 mm in size treated with mini-perc ( $n = 106$ ) or RIRS ( $n = 95$ ). Stone-free status levels were 84% for RIRS and 86% for mini-perc, while complication levels were 8.4% for RIRS and 17% for mini-perc. All complications in both groups were minor (Clavien I-II), and no major complications (Clavien III-IV) were observed. However, transfusion requirement at a level of 6% was reported in the mini-perc group. In addition, exposure to fluoroscopy, length of surgery and length of hospital stay were all lower in the RIRS group. Although RIRS appears to offer more advantages than mini-perc, when preoperative factors were assessed, there was a significant difference between the two groups in terms of stone size (23.7 mm *vs* 14.3 mm), and this was cited as a significant limitation in the text. When the groups

**Table 2** Comparison of percutaneous nephrolithotomy and retrograde intrarenal surgery data in a recent study by Resorlu *et al*<sup>[30]</sup> n (%)

	PNL	RIRS
No. patients	106 (52.7)	95 (47.3)
Mean fluoroscopy time ± SD (s)	113.7 ± 36.6	33.2 ± 14.6
Mean operative time ± SD (min)	76.3 ± 21.2	42.1 ± 15.3
Mean hospitalization time ± SD (d)	3.1 ± 1.2	1.7 ± 0.6
Initial stone-free rate	91 (85.8)	80 (84.2)
Stones ≥ 20 mm	78/93 (83.9)	4/8 (50.0)
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 (17.0)	8 (8.4)
Major (Clavien III–IV) complications	-	-
Blood transfusion rate	7 (6.6)	-

PNL: Percutaneous nephrolithotomy; RIRS: Retrograde intrarenal surgery.

were compared again in terms of stone size, success rates of 87% in the RIRS group and 100% in the mini-perc group were obtained in stones of 1-2 cm, and 50% in the RIRS group and 84% in the mini-perc group in stones of 2-3 cm. The success rate of RIRS falls markedly when stone size exceeds 2 cm. In the light of these results, the authors reported that RIRS is superior to mini-perc in stones less than 2 cm in size, but that mini-perc has a better success rate with larger stones, and that RIRS can represent an alternative to it.

As technology has advanced, thinner and more resistant ureteroscopes and lithotripters with a greater deflection capacity and image quality have been developed<sup>[31]</sup>. This has made it easier to break stones at all points in the kidney. In the light of all these advances and increasing experience, the success rate of RIRS has increased and indications for use have widened, and it has now assumed a place together with SWL and PNL methods among treatment options for renal stones in children.

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