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Recent management of urinary stone disease in a pediatric population

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Abstract

The incidence of stone disease has been increasing and the risk of recurrent stone formation is high in a pediatric population. It is crucial to use the most effective method with the primary goal of complete stone removal to prevent recurrence from residual fragments. While extracorporeal shock wave lithotripsy (ESWL) is still considered first line therapy in many clinics for urinary tract stones in children, endoscopic techniques are widely preferred due to miniaturization of instruments and evolution of surgical techniques. The standard procedures to treat urinary stone disease in children are the same as those used in an adult population. These include ESWL, ureterorenoscopy, percutaneous nephrolithotomy (standard PCNL or mini-perc), laparoscopic and open surgery. ESWL is currently the procedure of choice for treating most upper urinary tract calculi in a pediatric population. In recent years, endourological management of pediatric urinary stone disease is preferred in many centers with increasing experience in endourological techniques and decreasing sizes of surgical equipment. The management of pediatric stone disease has evolved with improvements in the technique and a decrease in the size of surgical instruments. Recently, endoscopic methods have been safely and effectively used in children with minor complications. In this review, we aim to summarize the recent management of urolithiasis in children.

Key words: Stone disease; Pediatric population; Urolithiasis; Surgical management

Core tip: The incidence of stone disease has been increasing and the risk of recurrent stone formation is high in a pediatric population. In recent years, endourological management of pediatric urinary stone disease is preferred in many centers with increasing experience in endourological techniques and decreasing sizes of surgical equipment. The management of pediatric stone disease has evolved with improvements in the technique and a decrease in the size of surgical instruments. Recently, endoscopic methods have been safely and effectively used in children with minor complications. In this review, we aim to summarize the recent management of urolithiasis in children.

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INTRODUCTION

Children with urinary stone disease represent the high risk group for stone recurrence[1]. Since the recurrence rate is higher in children compared to adults, ideally no residual stone fragments should be left behind after any treatment for urinary stones. A previous study showed that 69% of children with residual stone fragments ≤

5 mm following extracorporeal shock wave lithotripsy (ESWL) had an increase in stone size[2].

The standard procedures to treat urinary stone disease in children are the same as those used in an adult population. These include ESWL, ureterorenoscopy (URS), percutaneous nephrolithotomy (standard PCNL or mini-perl), laparoscopic and open surgery. ESWL is currently the procedure of choice for treating most upper urinary tract calculi in a pediatric population[3]. In recent years, endourological management of pediatric urinary stone disease is preferred in many centers with increasing experience in endourological techniques and decreasing sizes of surgical equipment[1,3]. This review aims to summarize the recent management of children with urinary stone disease.

ESWL

The use of ESWL in the treatment of urinary stones in a pediatric population was first reported by Newman *et al*[4] in 1986. ESWL is the preferred treatment in pediatric urinary stone patients with uncomplicated upper urinary tract calculi $\leqslant$ 15 mm[1,3,5,6]. Although stone free rates after ESWL in children range between 68% and 92%, recent stone free rates are difficult to interpret from the current literature due to discrepancies among trials with regard to the lithotripter model used, number of shocks administered and re-treatment rates[1,3,7,8]. Factors which decrease ESWL success rates include increased mean stone burden, increased infundibular length, infundibulopelvic angle greater than 45 degrees, harder stones such as cysteine and whewellite, and lower pole localization[1,9]. In a recent study, the authors aimed to define the preoperative kidney and stone characteristics on noncontrast-enhanced computed tomography that affect the success of ESWL for treatment of renal calculi in pediatric patients. The authors concluded that stone attenuation $\leqslant$ 600 HU and stone length $\leqslant$ 12 mm were significant independent predictors of ESWL success in children[10]. ESWL monotherapy has superior success rates in children compared to adults due to relatively softer stone composition, smaller relative stone volume, smaller body volume to facilitate shock transmission, and easier spontaneous stone passage due to increased ureteral compliance to accommodate stone fragments[1,3,11-13]. In children, ureteral stenting before ESWL is not needed as often as in adults and it is not clear if ureteral stent placement improves stone free outcomes[1,3,11]. ESWL can cause minor complications, including hematuria, perirenal hematoma, bruising and renal colic[1]. Although ESWL has low complication rates, the stone free rate after a single session is approximately 45%[3,14]. The need for multiple ESWL sessions is controversial since anesthesia is required and the effects of shock waves on renal tissue are not clear[1,3,15].

In a previous study, the authors found no negative effect of ESWL on renal function or blood pressure[16]. In another study, the authors found no significant changes in blood pressure or signs of acquired parenchymal renal scarring following ESWL in children[17]. Vlajković *et al*[18] evaluated glomerular filtration rate (GFR) before and after ESWL. The authors showed that GFR normalized or improved at the 3rd month after the ESWL procedure and concluded that ESWL is a safe treatment in children. In a previous epidemiological and questionnaire based retrospective study, the authors found that the patients treated with ESWL had an increased risk of developing hypertension and diabetes mellitus when compared to controls[19]. In contrast, in a different study, the authors prospectively examined 12 patients after ESWL and concluded that it is unlikely that ESWL and diabetes mellitus are related[20].

PCNL

After it was first described in children in 1985, several studies reported the use of PCNL in children with urinary stone disease using adult sized surgical instruments with high success and acceptable complication rates[21-24]. In 1998 Jackman *et al*[25] introduced a novel percutaneous access technique (mini-perc) and reported a 85% total success rate. The authors listed the benefits of this new technique as increased maneuverability, decreased blood loss and shorter hospital stay, with limitations including prolonged operative times and potential impairment of visualization during the procedure, especially for larger stones.

In a previous trial, the authors compared the results of percutaneous nephrolithotomy and shock wave lithotripsy for the treatment of 1 to 2 cm renal stones in children. They concluded that percutaneous nephrolithotomy is better than shock wave lithotripsy for treatment of 1 to 2 cm renal stones in children, yielding higher stone free and lower re-treatment rates[26].

Recently, the success rate of PCNL in a pediatric population was reported to be between 87% and 98.5%[11,23,26,27]. In a previous study, the authors reported the outcomes of 56 children who underwent PCNL[11]. The authors found a stone free rate of 89.8% and that the number and size of the access tracts were significantly associated with a postoperative hemoglobin decrease and transfusion rate. In a different study, the authors reported a 87% stone free rate following a PCNL procedure in 52 children with a mean age of 7.9 years[27]. The authors reported postoperative fever in 30% of the patients included in the study and a blood transfusion rate of 24%.

The European Association of Urology guidelines state that ESWL is the first choice for treating most renal pediatric stones and PCNL can be preferred for larger and complex stones. The guidelines also mention that PCNL can be used as monotherapy in most cases but is also used as an adjunctive procedure to other therapies[28]. Relative indications for PCNL as a primary therapy in a pediatric population include upper pole stones $\geqslant$ 1.5 cm, lower pole stones $\geqslant$ 1 cm, harder stones and potential anatomical abnormalities that can possibly impair urinary

drainage and thus stone clearance, such as ureteropelvic junction obstruction and ureter stricture[1,3]. Potential limitations for the use of a PCNL procedure in children include possible parenchymal damage and associated impairment in renal function, radiation exposure and the risk of major complications, including urinary sepsis and bleeding[3]. Some studies evaluated the potential loss of renal function due to renal scarring after PCNL in children[29,30]. In a previous study, the authors investigated renal scarring on a dimercaptosuccinate (DMSA) renal scan following PCNL and found no renal scarring on DMSA[29]. In the same study, a diethylenetriamine pentaacetic acid renal scan was used to follow-up renal function after PCNL and it was observed that renal function had improved or not changed, except for one patient.

PCNL can be used both as monotherapy and in combination with ESWL in children[3,7]. The use of PCNL in combination with ESWL is preferred to reduce the number of access tracts and associated morbidity rates. In a previous study, the authors reported a 60% stone free rate after PCNL. The stone free rate increased to 100% following an ESWL procedure[30]. In a similar study, the authors reported a 59% monotherapy stone free rate after PCNL in 169 children[24]. Thirty-four point five percent of children with residual stones were treated with ESWL and the overall stone free rate increased to 93.8%. Although PCNL is an invasive treatment, in experienced hands it can be effectively and safely used in children with large stone burdens with the use of smaller sized surgical instruments and more efficient energy sources used for stone fragmentation.

URS

Although previously URS was only used for ureter stones below the iliac crest and for upper urinary tract stones following an unsuccessful ESWL procedure in children, many clinicians prefer to use URS even in young children with the introduction of smaller diameter ureteroscopic instruments and holmium laser[1,3]. URS was first used in 1988 for distal ureteral calculi in children and the authors reported stone free rates between 86%-100% in the early series[1,7,12,13]. In a previous randomized study, the authors compared URS and ESWL in 31 children and found stone free rates of 94% and 43% in the URS and ESWL groups respectively[31]. In a different study, the authors reported their experience using 4.5, 6 and 8 Fr rigid URS for treating proximal ureteral stones in 24 children and reported a stone free rate of 100%[32]. Corcoran *et al*[33] reported the outcomes of 47 children with upper tract stones treated with flexible URS and holmium laser lithotripsy. They reported a stone free rate of 88% and 26% in the children requiring staged procedures.

There was a concern regarding the use of URS in children with urinary tract stones due to potential complications, including ureteral ischemia, ureteral stricture and vesicoureteral reflux (VUR). However, a previous review of 221 URS procedures in a pediatric population showed that only two children had ureteral strictures and eight had low grade VUR[13]. The introduction of flexible ureteroscopes which can bend up to 270° made the removal of renal stones in lower calices possible[1]. In a previous study, the authors reported the success rate of lower pole calculi removal as 76% in 21 children with a mean age of 15 years[34]. In a prospective randomized study comparing ESWL and URS for lower pole calculi up to 1 cm, after three months, 35% and 50% of the patients in the ESWL and URS groups respectively were stone free[35].

Smaller and more durable endoscopes with the introduction of laser technology for the fragmentation of urinary stones allow the use of URS in children to be more prominent. Relative contraindications for URS in children include staghorn stones, anatomical anomalies and previous unsuccessful endoscopic procedures[3].

LAPAROSCOPIC/ROBOTIC/OPEN NEPHROLITHOTOMY

Surgical treatment of children with larger stones is technically challenging. Open surgery is used more in developing countries compared to developed countries, probably due to cost effectiveness[1,3]. Open surgery is preferred in children with concomitant anatomical abnormalities, including ureteropelvic junction obstruction and obstructive megaureter[1,36]. In a previous study, the authors reported a 95.4% stone free rate in children who underwent open nephrolithotomy[37]. In a different study, the authors reported a success rate of 100% with no major complications in 8 children who underwent laparoscopic pyelolithotomy[38]. Lee *et al*[39] reported the outcomes of 5 children who were treated with robotic-assisted laparoscopic pyelolithotomy and mentioned that the technique is feasible and safe as an alternative to open surgery in children.

CONCLUSION

The management of pediatric stone disease has evolved with improvements in the techniques and a decrease in the size of surgical instruments. Recently, endoscopic methods have been safely and effectively used in children with minor complications.

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