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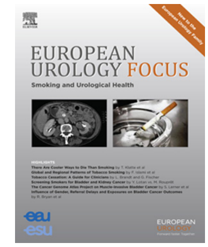

Review – Pediatric Urology

Update on Urinary Stones in Children: Current and Future Concepts in Surgical Treatment and Shockwave Lithotripsy

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Abstract

Context: Miniaturized instrumentation used for endoscopic treatment of urinary stone disease in children has been readily adopted in clinical practice. However, there is a need to optimize and individualize the surgical approach according to the patient's age, body habitus, and stone characteristics. Promising novel equipment and techniques will continue to advance the surgical care of these children.
Objective: To review the literature regarding surgical and shockwave lithotripsy (SWL) treatment of urinary stone disease in children and provide an overview on future treatment innovations.
Evidence acquisition: We conducted a nonsystematic review of the literature using the PubMed database. The search focused on the most recent two decades to provide a contemporary overview of surgical outcomes.
Evidence synthesis: Although SWL use has proportionally decreased over time, it remains an important treatment option for kidney stones <2 cm and upper ureteral calculi, with success rates between 49% and 97%. Rigid/semirigid ureteroscopy is the first-line therapy for distal ureteral stones and has success rates comparable to SWL for upper ureteral stones. Success rates between 80% and 100% are achieved with retrograde intrarenal surgery (RIRS) for kidney stones <2 cm but may require pre-stenting in smaller children. Mini percutaneous nephrolithotomy (PNL) is the most efficient technique for treating kidney stones in children. Micro-PNL and ultramini-PNL are valuable alternatives, especially for smaller renal stones.
Conclusions: Modern endoscopic treatment options together with SWL allow personalized management of stone disease in the pediatric population. Future technical improvements on the horizon offer the promise of increasing the efficiency of current procedures while minimizing complications.
Patient summary: Miniaturization of the instruments used for treatment of stone disease in children provides a variety of options for clinical practice. Rather than routinely using a single technique, personalized treatment is recommended to increase the success of each procedure.

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1. Introduction

The incidence of pediatric stone disease is significantly increasing worldwide [1]. Owing to the recurrent nature of urolithiasis in the pediatric population, there is no equivalent definition to the "clinically insignificant stone" used for adults. Therefore, every effort should be made to achieve stone-free status in the pediatric population. Treating urolithiasis in children is uniquely challenging owing to the smaller anatomical features of children. The need to optimize treatment success coupled with these challenges has necessitated improvements in technology and devices for surgical management of pediatric nephrolithiasis. Notable technological advances include a variety of versatile and increasingly smaller instruments and techniques, including flexible ureteroscopy (fURS), mini percutaneous nephrolithotomy (PNL), micro-PNL, and ultramini-PNL [2]. Open stone surgery is now rarely performed given the shift towards endoscopic treatment options.

According to the European Association of Urology/European Society for Paediatric Urology (EAU/ESPU) guidelines, shockwave lithotripsy (SWL) is still the first-line therapy for many cases of urinary stone disease in children [3]. However, advances in endoscopic technology and equipment mean that minimally invasive endoscopic treatment options can achieve high success rates while minimizing complications. As each treatment modality offers advantages and limitations, personalized management related to instrument availability and surgeon experience is critical in optimizing treatment outcomes.

Improved optical visualization via current endoscopic devices, implementation of robotic technology for stone disease treatment, improvements in stone baskets, and increased laser effectivity are some future concepts on the horizon.

In this review, we aimed to assess the contemporary literature regarding surgical treatment options and SWL for pediatric stone disease management. We also sought to provide an overview of potential future advances in technology that will become relevant for surgical management of pediatric nephrolithiasis in the coming years.

2. Evidence acquisition

2.1. Study selection

A comprehensive search of the PubMed database was performed, focusing on the last two decades.

2.2. Inclusion criteria

In this nonsystematic review, we included original articles in English related to surgical management of stone disease in children. In addition, SWL was included as it is considered a comparative treatment modality for stone disease. Furthermore, the EAU/ESPU guidelines on pediatric urology were used as a resource for the review.

For each procedure, separate searches for MeSH terms specific to treatment modality ("flexible ureteroscopy", "percutaneous nephrolithotomy", "miniperc", "microperc", "ultraminiperc", "retrograde intrarenal surgery", "shock wave lithotripsy") and "children" were performed. Priority was given to the contemporary literature, and evidence-based studies and articles published in journals with higher impact if similar methods were described.

3. Evidence synthesis

3.1. Surgical treatment options for stone disease in children

3.1.1. SWL

Since it was first described for pediatric nephrolithiasis in 1986, SWL has been a mainstay of treatment for both renal and ureteral calculi in children [4]. SWL is currently regarded as first-line therapy for most renal and upper ureteral calculi <2.0 cm according to the EAU/ESPU guidelines [3]. Meanwhile, the American Urological Association (AUA) considers SWL to be a first-line option along with URS for renal or ureteral calculi <2.0 cm, and a first-line option along with PNL for renal calculi >2.0 cm [5]. However, a critical view of SWL outcomes coupled with improved instrumentation for retrograde intrarenal surgery (RIRS) has resulted in a shift in practice across the USA and Europe, with lower rates of SWL compared to RIRS.

3.1.1.1. SWL outcomes in the pediatric population. Outcomes of SWL in children vary substantially with regard to stone-free and retreatment rates. Stone-free rates reported vary between 59.2% and 94.8% for children [6–13]. Retreatment rates are as high as 83% and may vary with the type of lithotripter and definition of treatment success (Table 1). Complication rates appear to range between 1.5% and 35%, depending on the definition of complications and follow-up [6]. Factors that appear to impact outcomes include stone composition, stone location, patient age, and, most importantly, stone size. Two nomograms have been developed to help stratify outcomes according to patient and stone factors, including gender, age, stone size and location, and history of previous interventions [14,15]. Patients with cystinuria or primary hyperoxaluria appear to respond poorly to SWL, with success rates typically <50% for each of these monogenic diseases, probably because of the relative densities of these calculi [16]. Young children may require general anesthesia with short hospitalization for pain control and adequate immobilization during extracorporeal treatment. While the skin-to-stone distance is a well-recognized predictive factor for success in adults, body mass index does not appear to impact outcomes in pediatric SWL, perhaps because of the lower overall skin-to-stone distance in children [17]. Stone attenuation as measured in Hounsfield units is associated with SWL success, although the clinical applicability of this assessment may be limited as many patients do not undergo computed tomography examination before surgery owing to the risks of ionizing radiation. Stone location and size are arguably the two most important predictors of success for SWL. While SWL has been successful for calculi even up to and surpassing 3 cm, the need for retreatment in these studies was high