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ARTICLE

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Shockwave lithotripsy and endourological stone treatment in children

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Abstract Urolithiasis in children is a rare disease in developed countries. Due to the particular anatomical conditions of the infant body, indications and results of the well-known treatment modalities, such as shockwave lithotripsy (SWL), ureteroscopy and PCNL, have to be determined. Experience in active stone treatment in children is very rare and only a limited number of papers are available. SWL can be performed only if focus size and treatment facilities are adapted to the size of the child. Miniaturization of ureteroscopes allows primary access to the infant upper urinary tract. Results, complications and morbidity of the treatment are similar to the results in adults. The main prerequisite for the primary endoscopic approach is the experience of the surgeon. PCNL should be performed as Mini-Perc. Percutaneous procedures show equal results and morbidity compared to the treatment of adults, in experienced hands. As two-thirds of infant stone patients have an underlying metabolic disorder, close cooperation of adult and pediatric urologists, nephrologists and radiologists is necessary in order to achieve good results in the treatment of infant stones.

Keywords Urolithiasis · Children · Extracorporeal shockwave lithotripsy · Percutaneous nephrolithotomy

Introduction

Urolithiasis in children is a rare disease in developed countries. Apart from the few cases that are managed in a general department of urology, usually there are no specialized equipment and experience available in a department involved in stone treatment of adults. Compared to the stone treatment in adults, there are some particular parameters which have to be mentioned regarding the stone treatment in children. There are quite different anatomic conditions in children, as the size of the urinary tract is smaller than that of adults. In addition, children have an increased ability to pass stone fragments spontaneously, due to a very mobile and flexible ureter. Almost two-thirds of all children suffering from stone disease have an underlying metabolic disease, which leads to an increased risk of stone recurrence. Due to the anatomical size of the urinary tract, special equipment for SWL and endourological procedures is required and enhanced experience of the surgeon is needed.

In general, the following are the treatment modalities: wait-and-see strategy in cases with small ureteral stones which can pass spontaneously, shockwave lithotripsy (SWL) as the treatment of choice, retrograde endoscopic procedures done by means of rigid or flexible instruments, percutaneous stone removal done by means of rigid or flexible endoscopes and which can be combined with antegrade flexible ureteroscopy, laparoscopic stone removal and open surgical procedures.

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Shockwave lithotripsy

Because of the body size of children, there are some prerequisites concerning the technical equipment in SWL in children. The table of the shockwave generator should be adapted to the size of the child and a particular fixation of the child is mandatory in order to get a reliable position of the child for the whole treatment time. The positioning system should be based on ultrasound and X-ray, in order to reduce X-ray exposition. Another prerequisite is to adapt the focus of the shockwave generator to the anatomical situation of the child (Fig. 1). Usual shockwave generators with a focus distance of 16 cm are not suitable to treat children.

If small calyceal or renal pelvic stones are treated in children, a high stone-free rate of up to 90% can be achieved and the retreatment rate is comparable to that in adults [1]. The effect of SWL in large stone burden is

Fig. 1 Extracorporeal shockwave therapy requires adjustment of shockwave equipment to the size of the child. The focus size and positioning system should be adapted to the body size

quite different. Ather showed that success and complication rates are related to the size of the stone. Almost 20% complications and 19% treatment failures show that SWL is not as suitable for big stones as for small stones. Lower pole stones show the poorest results [2–4]. One of the main problems after treatment by means of SWL is the clearance of residual fragments. Afshar showed that residual fragments after SWL in children are associated with a high risk of an adverse outcome like symptoms or stone growth. Often in these cases an underlying metabolic disorder can be detected. Twenty six of 88 cases treated with SWL showed residual fragments up to 5 mm. This study clearly shows that residual fragments are an important problem associated with

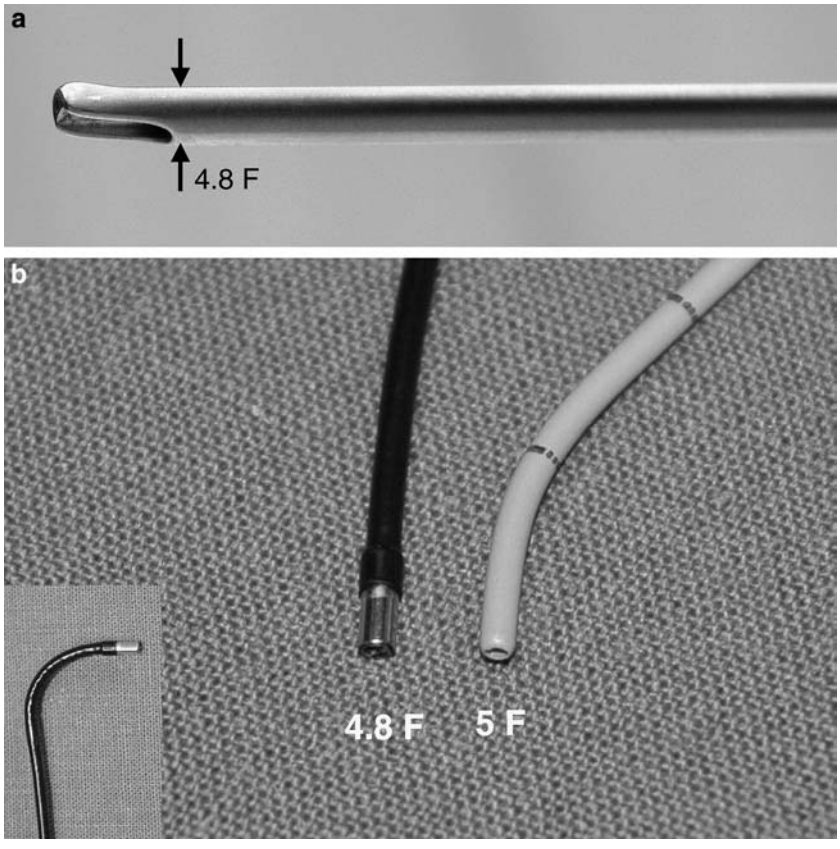

Fig. 2 Miniaturized instruments for ureteroscopy in small infants: **a** 4.8 F rigid instrument, **b** 4.8 F flexible instrument (prototype), with single side deflection of 90°

SWL in children—results that are similar to those in adults [5].

A study with a very large study population of 1,440 children was done by Rizvi. He showed that SWL of ureteral stones is not as effective as in stones of the upper urinary tract. SWL of ureteral stones is an effective procedure with low morbidity and a high stone-free rate. But interestingly 20% of all ureteral stones were managed by open surgical procedures. This means that SWL of ureteral stones is effective and associated with a low morbidity, but a high proportion of children have to undergo open surgical removal [6].

Another question is if SWL leads to a decrease of renal function in children. Vlajkovic reported interesting data about ^{99m}Tc-DTPA studies prior to and after SWL. Mid- and long-term follow-up of children after SWL showed an increased renal function. The conclusion of this study is that SWL can be performed in children without any long-term morbidity of the kidney [7].

Ureteroscopy

Due to the small infant ureter, particular instruments are necessary to enter the ureter. Miniaturized instruments have a diameter of less than 5 F (Fig. 2). Such ureteroscopes can easily be inserted into the ureter, even in small children. As the working channel is very small, Holmium Laser Lithotripsy and small stone retrieval devices are necessary. Flexible ureteroscopes for children have a diameter of 5 F. In older children, flexible and rigid ureteroscopes of adults can be used.

Ureteroscopy as a first line treatment was studied by Tan and co-workers. Overall stone-free rate was 95.2% and no intraoperative complication occurred. By means of miniaturized instruments, ureteroscopy in children is a safe and effective treatment modality. Based on these results, ureteroscopy could be offered as a first line therapy [8].

Another treatment option is to combine ureteroscopy and SWL. The overall stone-free rate in these cases is up to 92.0%. The prerequisite for performing ureteroscopy as a safe and effective treatment modality is the availability of small caliber instruments with a cross-section of less than 8 F. Only experienced urologists should perform ureteroscopy in children [9].

A never-ending story in the treatment of distal ureteral stones is the question whether SWL or ureteroscopy is suitable. A well-designed study was presented by De Dominicis et al. [10]. They performed a randomized trial including 31 children and found that the efficacy of SWL was less than that of ureteroscopy. Their conclusion is that ureteroscopy should be the treatment of choice for distal ureteral stones, even though both procedures, SWL and ureteroscopy, are done under general anesthesia in children. The use of a holmium laser in rigid ureteroscopy in children is mandatory. In experienced hands, ureteroscopy and lithotripsy using a holmium laser leads to an overall stone-free rate of 97.0% including adjuvant treatment modalities [11].

PCNL

When performing percutaneous procedures in children, the first question is what instruments to use. Most percutaneous procedures are done using conventional instruments with a diameter of 22–26 F. According to the small size of the infant kidney, miniaturized nephroscopes may be suitable.

Four years ago, a miniaturized nephroscope was introduced to perform Mini-Perc [12]. The nephroscope has a diameter of 12 F and is placed through an Amplatz sheath of 18 F. The nephroscope is a continuous-flow instrument which allows a clear view at any time. Working length is 225 mm, view angle is 12.5° and the working channel is 6 F. Comparing the Mini-nephroscope to the conventional nephroscope, there is a significant decrease of the cross-section, which avoids unnecessary damage of the renal tissue and allows a single-step dilation by means of a special dilator (Fig. 3). Even in small infants, the Mini-Perc procedure can be performed (Fig. 4).

There are only a few papers available dealing with percutaneous stone removal in children. Metaanalysis of five recent papers shows that often conventional nephroscopes are used. But all papers state a low complication and transfusion rate (Fig. 5). Based on these data PCNL is a safe and effective procedure in children.

Fig. 3 Comparison of a conventional instrument for PCNL and instrument for Mini-Perc: **a** Mini-Perc instrument of 12 F, **b** conventional instrument of 26 F

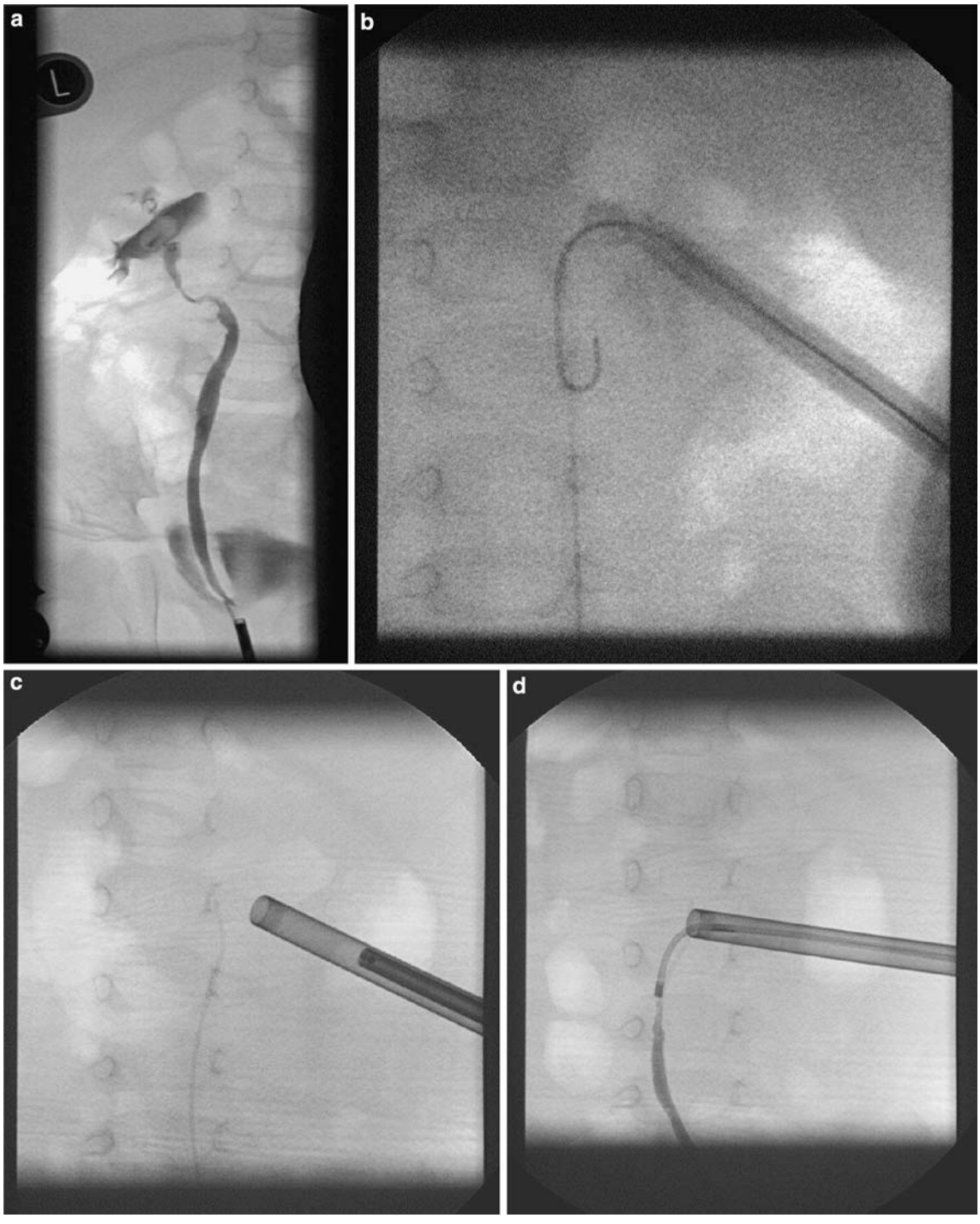

Fig. 4 Minimal invasive PCNL in a 9-month-old female child. **a** Retrograde pyelography demonstrating a renal pelvic stone of the right kidney. **b** Insertion of an 18 F Amplatz sheath. **c** X-ray examination after removal of the renal stone. **d** Antegrade flexible ureteroscopy by means of a 4.8 F flexible ureteroscope allows to remove residual stones and exclude ureteropelvic junction obstruction

It is so safe and effective that Salah et al. [13] published a paper about simultaneous bilateral PCNL in children. Of course this procedure could not be recommended as a routine procedure, but this paper shows that PCNL in children in experienced hands is a real effective treatment modality.

Another question is if PCNL decreases renal function in children. The answer is given in a study by Dawaba. He showed that GFR after PCNL increases compared to the preoperative level. No renal scarring was visible [14].

In order to complete the overview of the different treatment modalities and to define the indications for

Fig. 5 Results of percutaneous stone removal in children

	Desay (2004)	Mahmud (2004)	Salah (2004)	Boormanns (2005)	Salah (2005)
no.	116	29	135	23	13
nephroscope diameter [F]	22	17	26	18	26
stone mass [cm²]	-	2.35	5.07	6.0	2.0
stone-free rate [%]	89.8	60.0	98.5	81.0	100.0
pyelonephritis [n]	0.0	-	0.0	1.0	0.0
transfusion [n]	0.0	-	0.0	1.0	0.0

SWL and endourological procedures more precisely, a short statement regarding the open surgical treatment of stone disease should be added. Zargooshi gave a nice, accurate and precise description of open surgical procedures in stone treatment. Open surgical removal of stones is safe, effective, less expensive and easily available. These advantages are particularly important in less-developed countries [15].

Algorithm for stone treatment

Based on the data presented, ureteral stones should be treated according to the algorithm given in Fig. 6. Distal ureteral stones should be treated primarily by an endoscopic retrograde approach. The main advantage is the short treatment time, the high stone-free rate and the low complication rate. SWL is an alternative treatment option, but positioning of the child during treatment, general anesthesia and poorer results refer SWL to the second choice therapy. If the ureteroscopic approach has failed, ureterolithotomy should be performed. Mid or proximal ureteral stones should be treated by SWL. In case of failure, ureteroscopy or ureterolithotomy should be performed. In summary there is no significant difference between the treatment of ureteral stones in children and adults, except for the particular instruments and the experience of the urologist.

Renal stones without morphological obstruction of the urinary tract should be primarily treated by SWL (Fig. 7). In case of failure, PCNL—preferably Mini-Perc—should be performed. In case of morphological obstruction, a percutaneous approach or open surgical procedure is more advisable because of the possibility to correct anatomic abnormalities simultaneously.

Conclusion

In conclusion, there is a significant technological advance in endourological procedures which allows urinary calculi in children to be treated similarly to those in adults. In contrast to adults, comprehensive care of these children with full metabolic evaluation is mandatory. In order to achieve good results in the treatment of infant stones, close cooperation of adult and pediatric urologists, nephrologists and radiologists is necessary. SWL is the treatment of choice for upper urinary tract

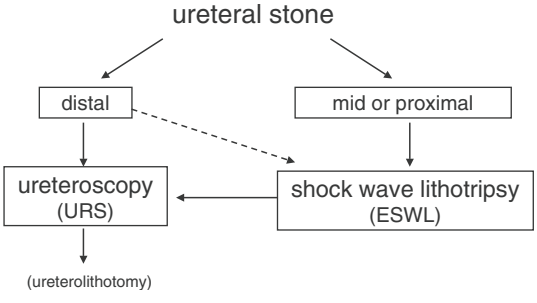

Fig. 6 Algorithm for the treatment of ureteral stones

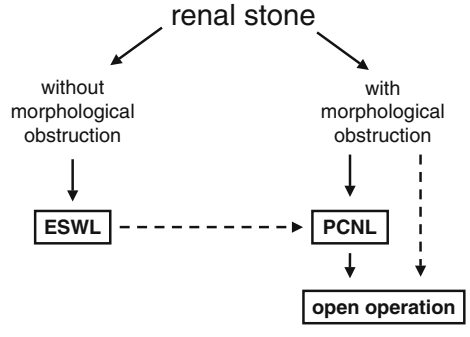

Fig. 7 Algorithm for the treatment of renal stones

stones in children. Particular attention should be paid to residual fragments and the identification of predisposing disorders. Lower pole stones should preferably be treated by PCNL. To optimize stone management, an endourological approach is necessary. Difficulties in endourological treatment are similar in children and adults. Miniaturized instruments and experienced hands are prerequisites for performing endoscopic stone treatment in children. If these prerequisites are fulfilled, ureteroscopy and PCNL are effective and safe.

References

1. Kuvdecic H, Tucak A, Peric N, Prlic D, Zoric I, Galic R (2003) ESWL treatment of urinary stones in children—the overview of 14 years of experience. Coll Antropol 27:71–75
2. Ather MH, Noor MA, Akhtar S (2004) The effect of intracalyceal distribution on the clearance of renal stones of > or =20 mm in children after extracorporeal lithotripsy. BJU Int 93:827–829
3. Al Bousaidy SS, Prem AR, Medhat M (2003) Pediatric staghorn calculi: the role of extracorporeal shock wave lithotripsy monotherapy with special reference to ureteral stenting. J Urol 169:629–633
4. Ozgür Tan M, Karaoglan U, Sen I, Deniz N, Bozkirli I (2003) The impact of radiological anatomy in clearance of lower calyceal stones after shock wave lithotripsy in paediatric patients. Eur Urol 43:188–193
5. Afshar K, McLorie G, Papanikolaou F, Malek R, Harvey E, Pippi-Salle JL, Bagli DJ, Khoury AE, Farhat W (2004) Outcome of small residual stone fragments following shock wave lithotripsy in children. J Urol 172:1600–1603
6. Rizvi SA, Naqvi SA, Hussain Z, Hashmi A, Hussain M, Zafar MN, Sultan S, Mehdi H (2003) Management of pediatric urolithiasis in Pakistan: experience with 1440 children. J Urol 169:634–637
7. Vlajkovic M, Slavkovic A, Radovanovic M, Siric Z, Stefanovic V, Perovic S (2002) Long-term functional outcome of kidneys in children with urolithiasis after ESWL treatment. Eur J Pediatr Surg 12(2):118–123
8. Tan AH, Al-Omar M, Denstedt JD, Razvi H (2005) Ureteroscopy for pediatric urolithiasis: an evolving first-line therapy. Urology 65:153–156
9. Raza A, Smith G, Moussa S, Tolley D (2005) Ureteroscopy in the management of pediatric urinary tract calculi. J Endourol 19:151–158
10. De Dominicis M, Matarazzo E, Capozza N, Collura G, Caione P (2005) Retrograde ureteroscopy for distal ureteric stone removal in children. BJU Int 95:1049–1052
11. Dogan HS, Tekgul S, Akdogan B, Keskin MS, Sahin A (2004) Use of the holmium:YAG laser for ureterolithotripsy in children. BJU Int 94:131–133
12. Lahme S, Bichler KH, Strohmaier WL, Götz T (2001) Minimal invasive PCNL in patients with renal pelvic and calyceal stones. Eur Urol 40:619–624
13. Salah MA, Tallai B, Holman E, Khan MA, Toth G, Toth C (2005) Simultaneous bilateral percutaneous nephrolithotomy in children. BJU Int 95:137–139
14. Dawaba MS, Shokeir AA, Hafez AT, Shoma AM, El-sherbiny MT, Mokhtar A, Eraky I, El-Kenawy M, El-Kappany HA (2004) Percutaneous nephrolithotomy in children: early and late anatomical and functional results. J Urol 172:1078–1081
15. Zargooshi J (2001) Open stone surgery in children: is it justified in the era of minimally invasive therapies? BJU Int 88:928–931