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ORIGINAL ARTICLE

The role of mini-PCNL as primary approach for the treatment of pediatric kidney stones in a high-income country. Ten-year single-center report

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Abstract

Purpose To describe our experience in the use of percutaneous nephrolithotomy (PCNL) as a primary treatment for paediatric kidney stones and to highlight its benefits.

Methods The design was retrospective and observational. All the children treated for kidney stones from 2011 to 2021 were included. The population was divided into Group A (PCNL) and Group B (retrograde intrarenal surgery, RIRS). The outcomes were stone-free rate (SFR), the rate of procedures per patient, the rate of failure and the rate of complications.

Results Twenty-eight patients with 33 kidney units were included. Eighteen of them (64%) were males. The median age was 10 (IQR 6.8–13) years. Forty-seven procedures were performed. Twenty-four of them (51%) were mini-PCNL. Group A included 17 patients (61%). Group A presented a higher SFR ($p = 0.007$) and a lower number of procedures ($p < 0.001$). RIRS failed in five cases (45%) because of non-compliant ureter. Two urinary tract infections (UTI) were reported after PCNL and four UTIs after RIRS ($p = 0.121$). No major complications were reported.

Conclusion Mini-PCNL should be suggested as a primary approach for pediatric kidney stones. This technique presented a better effectiveness with a reduced number of procedures when compared to RIRS.

Keywords Kidney stones · Children · Nephrolithotomy · Retrograde intrarenal surgery · Prone

Introduction

The epidemiology of pediatric urolithiasis has been changed in the last decades [1]. Currently, the prevalence of pediatric stone disease is different among low-income and high-income countries, where urinary stones involve the upper urinary tract in 75–80% of the patients [2].

Nowadays, several endoscopic procedures, such as percutaneous nephrolithotomy (PCNL) and retrograde intrarenal surgery (RIRS), are safe and feasible in pediatric population thanks to introduction and the improvements of new endoscopic devices specifically designed for the treatment of pediatric kidney stones [3]. Consequently, the need for surgical interventions decreased to a ratio 1:10 in the last years [4]. Nevertheless, most of the evidence about this topic came from the studies in the adult population or from low-income countries [5].

Despite this significant improvement, the current evidence about the minimally invasive treatment of pediatric kidney stones requires further investigation. PCNL seemed to be extremely effective as a primary approach for the management of kidney stones with a stone-free rate (SFR) ranging from 75 to 84% in preschool age [6].

The aim of this work was to describe ten-year experience in the management of pediatric kidney stones in a high-income country. The secondary aim was to report and compare the outcome of PCNL as a primary approach for the treatment of pediatric kidney stones.

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Material and methods

Study design and population

The design of the study was retrospective and observational. Our Institutional Review Board (IRB) was notified and approved the study (928/2022/OSS*/AOUMO). All the patients treated between January 2011 and December 2021 at our University-Hospital were enrolled. The inclusion criteria were age inferior to 18 years and the involvement of the upper urinary tract. The patients affected by isolated ureteral stones were excluded.

For the purpose of the study, the population was split into two groups. The Group A included patients first approached by PCNL, whilst Group B included those first approached by RIRS.

The initial approach was chosen after a multidisciplinary assessment together adult urologists who were mentoring the endoscopic procedures. The criteria for the choice included patients' characteristics, such as age and body size, together with stone characteristics, such as dimension, localization, and composition.

The following variables were compared between the two groups: age, gender, number, size and position of the stones, the presence of staghorn stones and the Guy's Stone Score [7].

The following aspect were considered as outcomes to compare: the length of patient positioning in the operative room, the length of surgery, the length of hospital stay, the number of failed attempts for endoscopic interventions, the number of endoscopic interventions per patient and the SFR. The latter was assessed by an ultrasound tomography performed four weeks after the procedure. Finally, complications and adverse events were scored according to Clavier-Dindo Classification [8]. The rate was compared between the two groups.

Endoscopic procedures

PCNL was performed in prone position. The access to renal calyces was guided by ultrasonography. All the procedures were mini-PCNL. The surgeons could have chosen between two different sets of devices according to patient's age and body weight. The first one included a 12 Fr nephroscope with a 16.5/17.5 Fr operating sheath and the second one included a 7.5 Fr nephroscope with a 11/12 Fr operating sheath. At the end of the procedure, a nephrostomy tube was left in place for the following 5–7 days.

RIRS was performed in Galdakao-modified supine Valdivia position [9]. A 7 Fr semi-rigid ureteroscope and a 7.5 Fr flexible fiberscope were used to reach the renal calyces under x-ray and direct vision. A 9 Fr ureteral operating sheath was available. The procedure ended with the placement of a double-J ureteral stent. The stent was removed within four weeks.

Holmium laser fibers were available to perform lithotripsy for both the approaches.

Statistics

The statistical analysis was performed by using IBM® SPSS Inc. Version 26.0. Categorical variables were reported as number (%) and continuous variables were reported as median value and inter-quartile range (IQR). The variables and the endpoints of the two groups were compared through a univariate analysis. Pearson's chi-squared tests were used for categorical variables and Mann–Whitney U tests were used for continuous variables. p value ≤ 0.05 was considered statistically significant.

Results

Population

In the study period 37 patients were treated for urolithiasis of the upper urinary tract for a total of 56 endoscopic procedures. However, seven patients (9%) were excluded due to exclusive ureteral localization of the stone. Two others (5%) underwent endoscopic combined intrarenal surgery (ECIRS) and were excluded. The remaining 28 (76%) were eligible for the study. Of the latters, 18 were males (64%). The median age was 10 years (IQR 6.8–13 years). Thirty-three kidney units were involved in the study, and 47 endoscopic procedures were performed.

Seventeen patients (61%) were included in the Group A, since they underwent mini-PCNL as primary approach. In the remaining 11 patients (39%) a RIRS procedure was indicated as first approach and they were included in Group B (Fig. 1).

The demographic and clinical characteristics of the two groups were similar, except for the size of the stones which was higher in the Group A ($p = 0.017$) and the bilateral involvement, higher in the Group B ($p = 0.047$) (Table 1).

Group A presented a median length of patient positioning of 50 (IQR 45–60) minutes, which was similar to Group B ($p = 0.303$).

The median length of surgery for Group A was 180 (IQR 145–220) minutes which was significantly higher than Group B ($p = 0.002$). Moreover, Group A presented a higher median length of hospital stay of 7 (IQR 6–10) days ($p = 0.041$). However, the stone-free rate of the Group A was significant higher ($p = 0.007$) with a lower number of procedures per

patient ($p < 0.001$). Finally, it is relevant to report that RIRS failed in five attempts ($p = 0.006$), and the procedures ended with ureteral stenting (Table 2).

As to the female gender, five girls (50%) belonged to the Group B. The ureterovesical junction was not accessible in three of them. After four weeks from the first attempt, mini-PCNL was performed with 100% success in terms of stone free-rate. In the remaining two patients the procedure did not reach a stone-free status. On the other hand, five female patients underwent mini-PCNL, and an 80% stone-free rate was reached.

In our series no events graded more than Clavien-Dindo III were reported. Six episodes of febrile urinary tract infections out of 47 procedures (13%) occurred. Two infections (8.3%) affected patients after mini-PCNL, whilst the other four episodes (17%) occurred after RIRS. Nevertheless, there was no difference between the two groups ($p = 0.121$).

Discussion

Both approaches presented a similar length for patients' positioning, even though mini-PCNL was performed in prone position. Mini-PCNL presented a higher stone-free rate with a lower number of endoscopic procedures per patient. On the other hand, in our series this approach presented a higher length of surgery and longer hospital stay. Finally, no major adverse events were reported for both

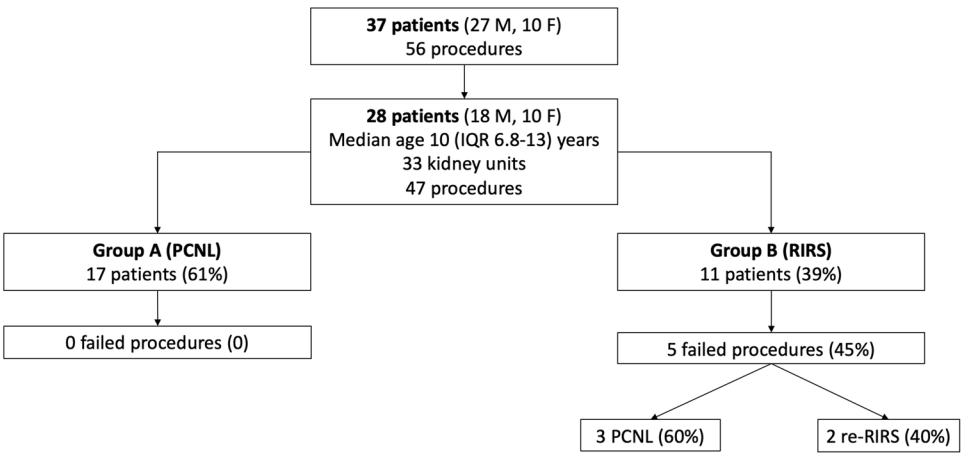

Fig. 1 Population included in the study

Table 1 Clinical and demographic characteristics of the two groups

	Group A (n = 17)	Group B (n = 11)	p value
Age (Median, IQR)	10 (6.0–11) years	9.0 (7.0–13) years	0.984
Gender			
Male (n, %)	12 (71%)	6 (55%)	0.387
Multiple stones (n, %)	8 (47%)	8 (73%)	0.180
Bilateral involvement (n, %)	1 (5.9%)	4 (36%)	0.047
Maximum size (Median, IQR)	16 (14–18 mm)	11 (10–16) mm	0.017
Lower calix involvement (n, %)	10 (59%)	7 (64%)	0.799
Staghorn stones (n, %)	6 (35%)	2 (11%)	0.328
Guy's stone score > II (n, %)	12 (71%)	9 (82%)	0.503

Table 2 Outcomes compared between the two groups

	Group A (n = 17)	Group B (n = 11)	p value
Length of patients' positioning (Median, IQR)	50 (45–60) min	40 (40–55) min	0.303
Length of surgery (Median, IQR)	180 (145–220) min	105 (85–130) min	0.002
Length of hospital stay (Median, IQR)	7 (6–10) days	4 (4–6) days	0.041
Failed attempts (n, %)	0 (0)	5 (45%)	0.006
Number of procedures per patient (Median, IQR)	1 (1–2)	3 (3–5)	< 0.001
Stone-free rate (n, %)	12 (71%)	2 (18%)	0.007

approaches and no difference in rate of complications was found.

The results of our series presented several hot topics about the current management of pediatric kidney stones. First, the safety of the endoscopic procedures was confirmed. It is important to underline the relevance of learning-curve to achieve this goal, especially for PCNL. A recent paper identified a cut-off of 60 procedures to reach an appropriate competence [10]. Given the relative rarity of pediatric kidney stones, pediatric surgeons or pediatric urologists might benefit from a mentoring program by adult urologists to improve their skills and to become autonomous. Second, several tricks were adopted to reduce the risk of complications. The smallest and miniaturized devices were chosen, especially in younger children. Guidewires and pyelographic control were always used, as suggested by EAU/ESPU guidelines [11]. Finally, a ureteral sheath was used whenever it was feasible.

Our data found better outcomes for PCNL in terms of success of the procedure. Almost half of the RIRS failed because of non-compliant ureteral meatus, especially in younger children. The procedures ended with a ureteral stenting. Moreover, half of the RIRS failed in female patients. For this reason, the different urethral anatomy might have not played a significant role, and the limiting factor for the progression of the ureteroscope mainly resided in the compliance of the ureterovesical junction. However, the sample size was too small to draw conclusions about differences between genders.

In literature there is no consensus about the need of ureteral pre-stenting before endoscopic procedures in children. This maneuver should be performed in case of failure to advance the device through the ureter to avoid severe complications [12].

As to the stone-free rate, the topic is controversial. Recent studies reported that RIRS presented similar efficacy to PCNL when treating stones smaller than 2 cm in both endemic and non-endemic countries [13, 14]. However, a clinical trial aiming to compare the outcomes of the different approaches has been started and further evidence might be provided by the results of this study [15].

Even though the efficacy of extracorporeal shockwave lithotripsy (ESWL) is similar in case of urinary stones larger less than 2 cm localized in the renal pelvis, the current trends in pediatric population showed an increased preference for endoscopic procedures [16]. This might be explained by several considerations. First, ureteral stenting should be recommended in most of the case to reduce the risk of complications, especially "steinstrasse" urinary obstruction [11]. Second, sedation or general anesthesia might be required during the sessions of ESWL. For these reasons, the children might be exposed to a higher number of procedures and anesthesia when compared to endoscopic techniques. Finally, a further consideration might be logistic and economic. Given the epidemiology of pediatric urinary stones, the number of ESWL procedures might not justify the costs and the device might not be available in every hospital.

Our data found a slight increase of the surgery time for PCNL. This might be due to a learning-curve effect, even though the procedure was mentored by experienced adult urologists. Moreover, a bias selection might have influenced this aspect. Even though no difference was found between the two groups, more complicated stones in younger children were approached by mini-PCNL.

The position of the patient did not influence the length of the surgery since no difference was found between the two approaches. This was due to the experience of the anesthesiologists and nurses that were used to deal with this position for other surgical procedures. In most of pediatric cases prone position was preferred because of the better ultrasonographic visualization of the kidney to reduce the risk of accidental bowel injuries during the puncture of renal calyces, especially in case of intestinal anomalies [17]. On the other hand, a recent comparative study found several advantages for supine position, including a higher stone-free rate and a higher number of tubeless procedures, net of higher time of fluoroscopy [18].

However, in our series the prone position was not a contraindication for endoscopic combined intrarenal surgery (ECIRS) and two of these procedures were safely performed. In these cases, the prone position might have prolonged the length of the surgery because of the need for patient's mobilization.

As to RIRS, a Galdakao-modified supine Valdivia position was chosen for its benefits in terms of a better straightening and drainage of the upper urinary tract [9]. This might ease the advance of the ureteroscope and the retrieval of stone fragments. Furthermore, in case of intraoperative complication, a nephrostomy could be placed without the mobilization of the patient.

In our series, patients after PCNL presented a longer hospital stay since the patients were discharged after the removal of the nephrostomy. The need for urinary derivation after endoscopic lithotomy is another controversial topic since the outcomes of tubeless procedures were positive thanks to the miniaturization of the devices [19]. Nevertheless, a careful selection of the patients should be suggested [20].

The main limitation of the study resides in the retrospective design that impacted on the definition of the criteria for the choice of the approach. A second limitation concerned the size of the population which was limited when compared to series in other countries [6]. Finally, the difference in the stone size between the group could be considered a selection bias that might have impacted in the choice of the initial approach and on the outcomes.

To conclude, mini-PCNL presented better outcomes with a lower number of procedures. For this reason, mini-PCNL should be suggested as a primary approach for the treatment of pediatric kidney stones. RIRS should be considered as a complementary procedure, especially in patients with high risk of recurrency or bilateral involvement. Finally, a mentoring program by adult urologists should be considered to optimize the outcomes of these procedures.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by FG, VD and PLC. The first draft of the manuscript was written by FG, FF and CDP. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the IRB (928/2022/OSS*/AOUMO).

Informed consent Informed consent was obtained from legal guardians.

Standards of reporting Authors adheres to the STROBE guidelines hosted by the EQUATOR Network.

References

1. Sas DJ, Hulsey TC, Shatat IF et al (2010) Increasing incidence of kidney stones in children evaluated in the emergency department. J Pediatr 157(1):132–137
2. Ozokutan BH, Küçükaydin M, Gündüz Z et al (2000) Urolithiasis in childhood. Pediatr Surg Int 16(1.2):60–3
3. Paraboschi I, Gnech M, De Marco EA et al (2022) Pediatric urolithiasis: current surgical strategies and future perspectives. Front Pediatr 10:886425
4. Seklehner S, Laudano MA, Chughtai B et al (2013) Trends in the utilization of percutaneous and open nephrolithotomy in the treatment of renal calculi. J Endourol 27(8):984–988
5. Barreto L, Jung JH, Abdelrahim A et al (2018) Medical and surgical interventions for the treatment of urinary stones in children. Cochrane Database Syst Rev 6:CD010784
6. Haberal HB, Dogan HS, Citamak B et al (2020) Outcomes of percutaneous nephrolitotmy in preschool age group: a single-center study. J Endourol 34(10):1001–1007
7. Thomas K, Smith NC, Hegarty N et al (2011) The Guy's stone score – gradinf the complexity of percutaneous nephrolitotomy procedures. Urology 78(2):277–281
8. Clavien PA, Barkun J, de Oliveira ML et al (2009) The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg 250(2):187–96
9. Ibarluzea G, Scoffone CM, Cracco CM et al (2007) Supine Valdivia and modified lithotomy position for simultaneous anterograde and retrograde endourological access. BJU Int 100(1):233–236
10. Wang X, Zhang Y, Zhao F et al (2022) Learning curves of flexible ureteroscopy (275 cases) and prone percutaneous nephrolithotomy (73 Cases) in pediatric stones: data from 348 children. J Endourol 36(11):1502–1508
11. Radmayr C, Boagaert G, Burgu B, et al EAU Guidelines on Pediatric Urology. http://uroweb.org/guideline/paediatric-urology/. Accessed 1 Dec 2022
12. Corcoran AT, Smaldone MC, Mally D et al (2008) When is prior ureteral stent placement necessary to access the upper urinary tract in prepubertal children? J Urol 180(4 Suppl):1861–1863
13. Bas O, Dede O, Aydogmus Y et al (2016) Comparison of retrograde intrarenal surgery and micro-percutaneous nephrolithotomy in moderately sized pediatric kidney stones. J Endourol 30(7):765–770
14. Ferretti S, Cuschera M, Campobasso D et al (2021) Rigid and flexible ureteroscopy (URS/RIRS) management of paediatric urolithiasis in a not endemic country. Arch Ital Urol Androl 93(1):26–30
15. Ellison JS, Lorenzo M, Beck H et al (2022) Comparative effectiveness of paediatric kidney stone surgery (the PKIDS trial): study protocol for a patient-centred pragmatic clinical trial. BMJ Open 12(4):e056789
16. Quhal F, Al Faddagh A, Selcuk Silay M et al (2022) Paediatric stone management: innovations and standards. Curr Opin Urol 32(4):420–424
17. Emiliani E, Quiroz YY, Llorens E, at al (2022) Retrorenal colon in pediatric patients with urolithiasis: Is the supine position for PCNL advantageous? J Pediatr Urol S1477-5131(22)00336-9. **Online ahead of print**
18. Campobasso D, Bocchialini T, Bevilacqua L et al (2022) Comparison between prone and supine nephrolithotomy in pediatric population: a double center experience. Int Urol Nephrol 54(12):3063–3068
19. Softness KA, Kurtz MP (2022) Pediatric stone surgery: what is hot and what is not. Curr Urol Rep 23(4):57–65
20. Goktug NH, Yesil S, Ozturk U et al (2013) Totally tubeless percutaneous nephrolithotomy: selecting for success in children.Adv. Clin Exp Med 22(4):565–570