



Ukrainian Journal of Nephrology and Dialysis

Scientific and Practical, Medical Journal

Founders:

- State Institution «Institute of Nephrology NAMS of Ukraine»
- National Kidney Foundation of Ukraine

ISSN 2304-0238;
eISSN 2616-7352

Journal homepage: <https://ukrjnd.com.ua>

Research Article

A. Al-Zobaie¹, R. Aal Toma², F. Al-Waeli¹

doi: 10.31450/ukrjnd.4(76).2022.03

The effectiveness and safety of tubed and tubeless percutaneous nephrolithotomy types in the treatment of preschool-age pediatric kidney stones

¹Safeer Al-Imam Al-Hussein Hospital, Karbala, Iraq

²College of Medicine, University of Karbala, Karbala, Iraq

Citation:

Al-Zobaie A, Aal Toma R, Al-Waeli F. The effectiveness and safety of tubed and tubeless percutaneous nephrolithotomy types in the treatment of preschool-age pediatric kidney stones. Ukr J Nephrol Dial. 2022;4(76):16-25. doi: 10.31450/ukrjnd.4(76).2022.03.

Abstract. *The incidence of kidney stones in children has increased in recent years. Unlike adults, the treatment of pediatric kidney stones is more difficult because of the size of the stones and the high risk of recurrence.*

The present study aimed to evaluate the management of pediatric kidney stones with percutaneous nephrolithotomy in general and with both types of percutaneous nephrolithotomy (PCNL).

Methods. *This retrospective cross-sectional study was conducted at Al-Safeer Al-Imam Al-Hussein Hospital from November 1, 2019 to October 31, 2021. A total of 90 children with kidney stones were divided into 45 with tubular PCNL and 45 with tubeless PCNL. The children were followed up for at least six months postoperatively.*

Results. *After PCNL, only 4 children were not stone-free and no injury was noted, whereas sepsis was noted in only one child. Renal status after PCNL was stable renal function in 97.8% of children and improved renal function in 2.2% of children, while no deterioration of renal function was noted. The characteristics of the children, the characteristics of the surgical procedure (except access), and the results of PCNL were not significantly different among the different types of PCNL.*

Conclusion. *PCNL in both variants (with and without tubing) is a safe and effective surgical option in the treatment of children with renal stones.*

Key words: *children, kidney stones, percutaneous nephrolithotomy.*

Conflict of interest statement. The authors declare no competing interest.

© A. Al-Zobaie, R. Aal Toma, F. Al-Waeli, 2022.

Correspondence should be addressed to Ali Al-Zobaie: medicalresearch55@yahoo.com

Article history:

Received July 13, 2022

Received in revised form

August 16, 2022

Accepted August 20, 2022



© Аль-Зобаї А., Аал Тома Р., Аль-Валі Ф., 2022

УДК: 616.62–003.7–053.2–085

А. Аль-Зобаї¹, Р. Аал Тома², Ф. Аль-Валі¹

Ефективність та безпечність перкутанної нефролітотомії в лікуванні сечокам'яної хвороби у дітей дошкільного віку

¹Госпіталь Сафір Аль-Імам Аль-Хусейн, Кербела, Ірак

²Медичний коледж Кербелського університету, Кербела, Ірак

Резюме. *Останніми роками зростає захворюваність на сечокам'яну хворобу (СКХ) у дітей. На відміну від дорослих, лікування СКХ у дітей є набагато складнішим через розмір каменів і високий ризик рецидиву.*

Метою цього дослідження було оцінити ефективність та безпечність перкутанної нефролітотомії (ПНЛТ) із застосуванням нефростоми та без такої у лікування СКХ у дітей.

Методи. *Ретроспективне перехресне дослідження, проведене в лікарні Аль-Сафір Аль-Імам Аль-Хусейн протягом періоду з 1 листопада 2019 р. по 31 жовтня 2021 р. Загалом 90 дітей із СКХ були розділені на 2 групи залежно від застосування нефростоми (n = 45) та без нефростоми (n = 45). Період спостереження склав щонайменше 6 місяців після операції.*

Результати. *Після ПНЛТ лише у 4 дітей були діагностовані конкременти нирок, травматичне пошкодження нирок не повідомлялось, тоді як сепсис було виявлено лише в 1 дитини. 97,8% дітей після ПНЛТ мали стабільну функцією нирок, у 2,2% з них спостерігалось покращення функції нирок і не було жодного повідомлення щодо зниження функції нирок. Характеристики дітей, особливості хірургічного втручання, за винятком доступу та результатів ПНЛТ суттєво не відрізнялись між групами.*

Висновки. *ПНЛТ обох типів (із застосуванням нефростоми та без такої) є безпечним і ефективним хірургічним методом у лікуванні дітей із сечокам'яною хворобою.*

Ключові слова: *діти, сечокам'яна хвороба, перкутанна нефролітотомія, нефростома.*

Introduction. Renal stone disease in children is a global health problem of multi-factors etiology. Incidence of pediatric nephrolithiasis had increased in the United States during the last twenty years to 6-10% in one year [1, 2], accompanied by high hospital admission and surgical treatment rates [3-5]. The incidence of childhood renal diseases in Iraq is high with the predominance of stone disease [6]. Gender variation is observed in pediatric renal stones with a higher risk in adolescent females [7]. Pediatric renal stones are found in all age groups with a high risk of recurrence rate. Additionally, frequency, composite and clinical features of renal stones in children differ in geographical variances, history of the disease, genetics, climate, diet, and socioeconomic status [8, 9]. Metabolic disease is the common etiology of pediatric renal stones among Iraqi children, followed by infection, anatomical abnormalities, idiopathy, and others [10]. The clinical presentation of pediatric renal stones is related to their age [8]. Abdominal or flank pain is the presentation of adolescents, while nausea, vomiting, and irritation are the presentations among younger age children with the rare feature of hematuria. However, many children with

nephrolithiasis are identified incidentally [11]. In addition to clinical features, laboratory and x-ray findings, the diagnosis of pediatric renal stones is based on ultrasound examination [12]. Exposure to high radiation in the diagnosis and management of renal stones must be avoided as possible. After medical conservative therapy of children, the surgical option is considered the treatment of choice. The common treatment choices for pediatric renal stones are extracorporeal shockwave lithotripsy, retrograde intrarenal surgery with ureteroscopy, and percutaneous nephrolithotomy (PCNL). The PCNL is commonly indicated in staghorn calculus, infected large renal stones and renal stones with anatomical abnormalities [13].

PCNL is associated with a stone-free rate of 70-97% [14], with a high success rate in stone size less than 2 cm [15]. Although the high stone-free rate of PCNL in children, many complications are reported with longer hospital stays [16]. Stone recurrence in children is widely reported after management with a rate of 19-34% rate after three years [17]. Preventive strategies like routine monitoring, high fluids intake, dietary modification, and medicines are required after PCNL in children with renal stones to avoid recurrence [18]. The first report of PCNL in children was in the United States in 1985 and from that date, the use of PCNL in the management of pediatric nephrolithiasis was slow. Recently with advances in medical and surgical technologies, the PCNL is replacing open surgery becoming an alternative to extracorporeal shockwave lithotripsy and ureteroscopy [19]. Conventionally, the PCNL is

Ali Al-Zobaie

medicalresearch55@yahoo.com

followed by the application of a nephrostomy tube and ureteral stent tube for adequate drainage preventing and assessing bleeding, and allowing the surgeons to second look for residual stones in the kidney. This method is accompanied by high discomfort and pain resulting from renal fistula and the long presence of ureteral stent [20]. For these reasons, many physicians and urologists revealed that tubed PCNL for patients with renal fistula leads to pain, discomfort, and long hospital stay as compared to tubeless PCNL is dependent on not placing nephrostomy and not accompanied by dangerous bleeding complications [21, 22].

After the advancement of PCNL in the last decades, the routine tubed technique was under question, with the advancement of significance for the tubeless technique [23]. Nephrostomy placement or displacement is related to many complications like discomfort, pain, infection, urinary leak, hemorrhage, and longer hospital stays [24]. To avoid or lower these adverse effects of the tubed technique, the tubeless PCNL is developed by inserting a double J ureter stent after the percutaneous nephrolithotomy [25]. In children, the tubeless PCNL showed similar effectiveness and outcomes reported for routine tubed PCNL with lower disadvantages of pain and discomfort reported for the latter technique [26, 27]. Although the advantages of tubeless PCNL are all over the world, this technique is slowly disseminated till now [28].

PCNL is the common surgical treatment option for the management of renal stones for adults and children in Iraq [29, 30]. The tubed PCNL is widely used in the management of pediatric nephrolithiasis in Iraq [30], however, recent advances by a little number of Iraqi surgeons revealed an appropriate efficacy and lower disadvantages of PCNL for adults and children by the implementation of the tubeless technique [31, 32]. For that, more research are required nationally and internationally to encourage physicians and surgeons to explore the advantage and disadvantages of the tubeless technique.

The present study aimed to evaluate the management of pediatric kidney stones with percutaneous nephrolithotomy in general and with both types of percutaneous nephrolithotomy

Materials and methods. The present project was a retrospective cross-sectional study implemented in the Safer Al-Imam Al-Hussein Hospital in Karbala governorate-Iraq through the period of two years from 1st of November 2019, to 31st of October 2021. The studied population was children with kidney stones admitted to the hospital. Inclusion criteria were pediatric-age patients (≤ 5 years) with kidney stones of size more than two centimeters. Exclusion criteria were older age children, positive urine culture, kyphoscoliosis, coagulopathy, and parents who refused to enrollment of children in the study. The study ethics were implemented regarding the Helsinki Declaration by documented agreement of parents, approved by the ethical committee in Medical College of Karbala University and hospital authority

in addition to managing future complications. A sample of ninety children with kidney stones was enrolled in the present study and divided into two groups according to PCNL techniques (45 children operated with tubed PCNL and 45 children with tubeless PCNL).

Information on children was collected directly by the researcher through a prepared questionnaire according to previously published data [21-23]. The questionnaire included general characteristics of children with kidney stones (age, gender, stone types [matrix or others], side of stone [right or left], opacity of stones [opaque or lucent], size of stones, and surgery history of kidney), surgical treatment features of children with kidney stones (PCNL type [tubed or tubeless], approach [upper, middle, lower and multiple] rheumatoid nodules, x-ray of hand with bone erosions, morning stiffness, ESR level, access [single or additive tract], blood transfusion, hepatitis, anomalies of kidney [double moiety or horseshoe kidney] and anesthesia [general or neuroaxial]), and PCNL outcomes (clearance, injuries, sepsis and renal status [stable, improved and declined]).

The diagnosis of kidney stones was done by the researcher according to history, clinical examination, laboratory, and ultrasound findings. The surgery of PCNL was done by the researcher after the approval of parents and most of the children were generally anesthetized. The children were set in lithotomy position first and the cystoscopy was placed then we put 3 fr. ureteric catheter under fluoroscopy then change position to prone position and start by injecting contrast in the catheter and using needle 18G by bull eye technique then insert guidewire and sequential dilatation did then use 12fr. nephroscope and we use the pneumatic device to destruct the stones and extract them by active grasper after completing the stones we put 3 or 4 fr Dj stents. The nephrostomy tube was put in the PCS if there is bleeding happened or during a preoperative period. Bacteremia was not resolved by antibiotics or if an injury to the pelvis happened.

The children were followed up for six months post-operatively by a second visit to a clinic or by phone calling to assess the outcomes of PCNL for each study group and manage any complications. The children's information was entered and interpreted statistically by the SPSS program-26. Data were presented as mean (M) and standard deviation (SD) and compared with the Student's test. The difference in group proportions was compared with the 2 test. Suitable statistical tests for data were implemented accordingly and a p-value of ≤ 0.05 was significant.

Results. In this study, ninety children with kidney stones were enrolled with a mean age of four years; the age of 2-3 years represented 31.1% of children, and the age of 4-5 years represented 68.9% of them. Male children with renal stones were more than females (61.1% vs. 38.9%). The matrix stones were present in only two studied children. Right-sided renal stones are present in 58.9% of children, while left-sided stones are present in

41.1% of them. About two-thirds (65.6%) of stones were opaque and 34.4% of them were lucent. The mean size of the stone was (30.1 mm) and 6.7% of children had previously operated kidneys (Table 1).

Table 1

General characteristics of children with kidney stones

Variable	No.	%
Age M±SD (4±1 years)		
2-3 years	28	31.1
4-5 years	62	68.9
Gender		
Male	55	61.1
Female	35	38.9
Stone types		
Matrix stone	2	2.2
Other stones	88	97.8
Side		
Right	53	58.9
Left	37	41.1
Opacity		
Opaque	59	65.6
Lucent	31	34.4
Size M±SD (30.1±14.7 mm)		
Surgery history of kidney		
No previous surgery	84	93.3
Previously operated kidney	6	6.7
Total	90	100.0

The PCNL was the treatment of choice for the studied children with renal stones; 50% of them by tubed PCNL and the other 50% of them by tubeless PCNL. PCNL approach used was commonly through the upper pole (76.7%); followed by; the middle pole (17.8%), lower pole (4.4%), and multiple poles (1.1%). The main access was single (97.8%) or addi-

tive tract (2.2%). No blood transfusion and hepatitis infection were reported. Anomalies of the kidney detected surgically were only horseshoe kidney (3.3%) and double moiety (1.1%). General anesthesia was implemented for 98.9% of children who had undergone PCNL, while neuroaxial anesthesia was used for only one child (Table 2).

Table 2

Surgical treatment features of children with kidney stones

Variable	No.	%
PCNL types		
Tubed	45	50.0
Tubeless	45	50.0
Approach		
Upper pole	69	76.7
Middle pole	16	17.8
Lower pole	4	4.4
Multiple poles	1	1.1

Continuation of Table 2

Variable	No.	%
Access		
Single access	88	97.8
Additive tract	2	2.2
Blood transfusion		
No	90	100.0
Hepatitis		
Negative	90	100.0
Anomalies		
Normal bilateral functioning kidneys	86	95.6
Double moiety	1	1.1
Horseshoe kidney	3	3.3
Anesthesia		
General anesthesia	89	98.9
Neuroaxial anesthesia	1	1.1
Total	90	100.0

A post-PCNL stone-free was detected in 95.6% of children and only four children had no stone free. The post-PCNL injury was not reported, while the sepsis was detected in only one child postoperatively.

Post-PCNL renal status was a stable renal function in 97.8% of children and improved renal function in 2.2% of them, while no reported declined renal function (Table 3).

Table 3

PCNL outcomes

Variable	No.	%
Clearance		
Stone free	86	95.6
No stone free	4	4.4
Injuries		
No	90	100.0
Yes	0	-
Sepsis		
No	89	98.9
Yes	1	1.1
Renal status		
Stable	88	97.8
Improved	2	2.2
Declined	0	-
Total	90	100.0

Children's general characteristics like age, gender, stone types, kidney side, stone opacity, stone size, and

surgery history of kidney were not significantly different regarding PCNL type (Table 4).

Table 4

Distribution of children's general characteristics according to PCNL types

Variable	PCNL types				P
	Tubed		Tubeless		
	No.	%	No.	%	
Age					0.17 NS
2-3 years	11	24.4	17	37.8	
4-5 years	34	75.6	28	62.2	
Gender					0.8 NS
Male	28	62.2	27	60.0	
Female	17	37.8	18	40.0	
Stone types					1.0 NS
Matrix stone	1	2.2	1	2.2	
Other stones	44	97.8	44	97.8	
Side					0.8 NS
Right	26	57.8	27	60.0	
Left	19	42.2	18	40.0	
Opacity					0.2 NS
Opaque	32	71.1	27	60.0	
Size					0.3 NS
M±SD	28.6±14.5		31.5±14.9		
Lucent	13	28.9	18	40.0	
Surgery history of kidney					0.3 NS
No previous surgery	41	91.1	43	95.6	
Previously operated kidney	4	8.9	2	4.4	

Tubed PCNL was significantly related to the middle pole approach, while tubeless PCNL was significantly related to the upper pole approach (p=0.002).

The access, anomalies, and anesthesia implemented were not significantly different concerning PCNL types (Table 5).

Table 5

Distribution of Surgical treatment features according to PCNL types

Variable	PCNL types				P
	Tubed		Tubeless		
	No.	%	No.	%	
Approach					0.002 S
Upper pole	30	66.7	39	86.7	
Middle pole	14	31.1	2	4.4	
Lower pole	0	-	4	8.9	
Multiple poles	1	2.2	0	-	
Access					0.1 NS
Single access	43	95.6	45	100.0	
Additive tract	2	4.4	0	-	

Continuation of Table 5

Variable	PCNL types				P
	Tubed		Tubeless		
	No.	%	No.	%	
Anomalies					0.5 NS
Normal bilateral functioning kidneys	44	97.8	42	93.3	
Double moiety	0	-	1	2.2	
Horseshoe kidney	1	2.2	2	4.4	
Anesthesia					0.3 NS
General anesthesia	44	97.8	45	100.0	
Neuroaxial anesthesia	1	2.2	0	-	

Although no significant difference in clearance outcome regarding PCNL types ($p=0.3$), 3 children had no stone-free after post-tubed PCNL, while only one child had no stone-free following tubeless PCNL. The sepsis

was not significantly different concerning PCNL types ($p=0.3$), however, one child had sepsis after tubeless PCNL. The renal status outcome was not significantly different regarding PCNL types ($p=1.0$) (Table 6).

Table 6

Distribution of PCNL outcomes according to PCNL types

Variable	PCNL types				P
	Tubed		Tubeless		
	No.	%	No.	%	
Clearance					0.3 NS
Stone free	42	93.3	44	97.8	
No stone free	3	6.7	1	2.2	
Sepsis					0.3 NS
No	45	100.0	44	97.8	
Yes	0	-	1	2.2	
Renal status					1.0 NS
Stable	44	97.8	44	97.8	
Improved	1	2.2	1	2.2	

Discussion. Until now, many surgeons preferred the classical PCNL using a nephrostomy tube in the management of pediatric kidney stones although it is associated with discomfort, pain, and longer hospitalization duration. To overcome these complications, new techniques were developed like mini-PCNL and tubeless PCNL [33, 34].

The present study showed a stone-free rate of (95.6%) for children with kidney stones treated by both techniques of PCNL. This stone-free rate is better than the results of Ebeid et al, [35] study in Egypt and Pelit et al, [36] study in Turkey which reported stone-free rates of (86.3% and 84.7%, respectively) after PCNL for children with nephrolithiasis. This higher stone-free rate of both PCNL techniques in our center is attributed to the advanced instruments used and highly ex-

perienced surgeons with adherent follow-up of patients. Our study also revealed no injuries with only one child with postoperative sepsis. This finding is close to the results of the Kagalkar et al, [37] study in India. In our study, no child had a declined renal status following PCNL, while 97.8% of children had stable renal status and 2.2% of them had improved renal status. Similarly, Lu et al, [38] studies in China reported higher efficacy with renal function stability following PCNL in children with urolithiasis.

The current study showed no significant difference in stone-free rate between tubed and tubeless techniques of PCNL of children with kidney stones ($p=0.3$). This finding coincides with the results of Iqbal et al, [26] retrospective study in Pakistan on 35 children with kidney stones grouped into 18 children surgically operated with

tubed PCNL and 17 children with tubeless PCNL and reported no significant difference in stone-free rate between the two groups. In a systematic review study conducted in the United Kingdom by Amer et al, [39] on 24 studies, the stone-free rate was not significantly different between tubed and tubeless PCNL techniques. Although no significant difference between tubed and tubeless PCNL techniques in postoperative sepsis ($p=0.3$), one child operated with tubeless PCNL had sepsis following the surgery. This finding is consistent with the results of an aal-Toma study in Iraq which found a significant association between children with kidney stones operated by tubeless PCNL and postoperative sepsis [32]. However, Abbott et al, [40] retrospective study in the USA revealed that tubeless PCNL was an effective and safe technique like tubed PCNL although a large proportion of urologists continued performing the tubed technique. Our study found similar renal status outcomes for children operated with both tubed and tubeless PCNL ($p=1.0$). This finding is similar to the results of Keshavamurthy et al, [41] retrospective study in India and Lee et al, [42] systematic review study in South Korea which stated that renal status outcome of tubed and tubeless PCNL was similar.

The general characteristics of children in the current study were not significantly different between tubed and tubeless PCNL ($p>0.05$). This finding is consistent with the results of many previous pieces of literature [26, 27, 43]. In the same manner, surgical characteristics like access, anomalies, and anesthesia of children were not significant between tubed and tubeless PCNL ($p>0.05$). This finding is similar to the results of the Xun et al, [44] meta-analysis study in China. The only sig-

nificant difference in the present study between tubed and tubeless PCNL was in the approach of surgery ($p=0.002$), as tubed PCNL was significantly related to the middle pole approach, while tubeless PCNL was significantly related to the upper pole approach. This finding coincides with the results of the aal-Toma study in Iraq [32]. It was shown that the upper pole approach of PCNL is effective in removing stones with lower postoperative complication rates [45].

Conclusion. This study concluded that percutaneous nephrolithotomy in both types (tubed and tubeless) is a safe and effective surgical option in the management of children with kidney stones. The tubeless technique of percutaneous nephrolithotomy has the same effectiveness and safety as the tubeless technique. The current study recommended that Urologists adopt the option of a tubeless technique of percutaneous nephrolithotomy in the management of pediatric nephrolithiasis to avoid complications of the tubed technique. Further national literature on the effectiveness and safety of tubeless percutaneous nephrolithotomy in children should be supported.

Conflicts of interest. The authors declare no competing interest.

Acknowledgment. Gratitude and thanks to the staff of Rzgary Hospital.

Funding. Non.

Authors' contribution. All the authors equally contributed to conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing – original draft preparation, writing – review & editing.

References:

1. *Sas DJ, Hulsey TC, Shatat IF, Orak JK.* Increasing incidence of kidney stones in children evaluated in the emergency department. *J Pediatr* 2010; 157(1):132–137. doi: 10.1016/j.jpeds.2010.02.004.
2. *Dwyer ME, Krambeck AE, Bergstralh EJ, Milliner DS, Lieske JC, Rule AD.* Temporal trends in incidence of kidney stones among children: a 25-year population-based study. *J Urol* 2012; 188(1):247–252. doi: 10.1016/j.juro.2012.03.021.
3. *Bush NC, Xu L, Brown BJ, Holzer MS, Gingrich A, Schuler B, et al.* Hospitalizations for pediatric stone disease in the United States, 2002–2007. *J Urol* 2010; 183(3):1151–1156. doi: 10.1016/j.juro.2009.11.057.
4. *Routh JC, Graham DA, Nelson CP.* Epidemiological trends in pediatric urolithiasis at United States freestanding pediatric hospitals. *J Urol* 2010; 184(3):1100–1104. doi: 10.1016/j.juro.2010.05.018.
5. *VanDervoort K, Wiesen J, Frank R, Vento S, Crosby V, Chandra M, et al.* Urolithiasis in pediatric patients: a single-center study of incidence, clinical presentation, and outcome. *J Urol* 2007; 177(6):2300–2305. doi: 10.1016/j.juro.2007.02.002.
6. *Ali SH, Hussien FS, Al-Amer HA.* Profile of Renal Diseases in Iraqi Children: A Single-Center Report. *Saudi J Kidney Dis Transpl* 2015; 26(3):613–618. doi: 10.4103/1319-2442.157422.
7. *Novak TE, Lakshmanan Y, Trock BJ, Gearhart JP, Matlaga BR.* Sex prevalence of pediatric kidney stone disease in the United States: an epidemiologic investigation. *Urology* 2009; 74(1):104–107. doi: 10.1016/j.urology.2008.12.079.
8. *Evan AP.* Physiopathology and etiology of stone formation in the kidney and the urinary tract. *Pediatr Nephrol* 2010; 25: 831–841. doi: 10.1007/s00467-009-1116-y.
9. *Sas DJ.* An update on the changing epidemiology and metabolic risk factors in pediatric kidney stone disease. *Clin J Am Soc Nephrol* 2011; 6: 2062–2068. doi: 10.2215/CJN.11191210.

10. *Ali SH, Rifat UN.* Etiological and clinical patterns of childhood urolithiasis in Iraq. *Pediatr Nephrol* 2005; 20:1453–1457. doi: 10.1007/s00467-005-1971-0.
11. *Turk C, Knoll T, Petrik AI, Sarica K, Skolarikos A, Straub M, et al.* Guidelines on Interventional Treatment for Urolithiasis. 2015. *Eur Urol*. 2016 Mar;69(3):475-82. doi: 10.1016/j.eururo.2015.07.041.
12. *Palmer JS, Donaher ER, O’Riordan MA, Dell KM.* Diagnosis of pediatric urolithiasis: role of ultrasound and computerized tomography. *J Urol* 2005; 174(4 Pt 1):1413–1416. doi: 10.1097/01.ju.0000173133.79174.c8.
13. *Long CJ, Srinivasan AK.* Percutaneous nephrolithotomy and ureteroscopy in children: evolutions. *Urol Clin North Am* 2015; 42(1):1–17. doi: 10.1016/j.ucl.2014.09.002.
14. *Hernandez JD, Ellison JS, Lendvay TS.* Current Trends, Evaluation, and Management of Pediatric Nephrolithiasis. *JAMA Pediatr* 2015; 169(10):964-970. doi: 10.1001/jamapediatrics.2015.1419.
15. *Donaldson JF, Lardas M, Scrimgeour D, Stewart F, MacLennan S, Lam TB, et al.* Systematic review and meta-analysis of the clinical effectiveness of shock wave lithotripsy, retrograde intrarenal surgery, and percutaneous nephrolithotomy for lower-pole renal stones. *Eur Urol* 2015; 67(4):612–616. doi: 10.1016/j.eururo.2014.09.054.
16. *De S, Autorino R, Kim FJ, Zargar H, Laydner H, Balsamo R, et al.* Percutaneous nephrolithotomy versus retrograde intrarenal surgery: a systematic review and meta-analysis. *Eur Urol* 2015; 67(1):125–137. doi: 10.1016/j.eururo.2014.07.003.
17. *Sarica K, Erturhan S, Yurtseven C, Yagci F.* Effect of potassium citrate therapy on stone recurrence and regrowth after extracorporeal shockwave lithotripsy in children. *J Endourol* 2006; 20(11):875–879. doi: 10.1089/end.2006.20.875.
18. *Chu DI, Tasian GE, Copelovitch L.* Pediatric Kidney Stones - Avoidance and Treatment. *Curr Treat Options Pediatr* 2016; 2(2):104-111. doi: 10.1007/s40746-016-0046-8.
19. *DeMarco RT.* Percutaneous Nephrolithotomy in Children. *Advances in Urology* 2011; Article ID 123606: 1-6. doi:10.1155/2011/123606.
20. *Fuller A, Razvi H, Denstedt JD, Nott L, Pearle M, Cauda F, et al.* The clinical research office of the endourological society percutaneous nephrolithotomy global study: outcomes in the morbidly obese patient e a case-control analysis. *J Endourol* 2011; 25:755-762.
21. *Yuan H, Zheng S, Liu L, Han P, Wang J, Wei Q.* The efficacy and safety of tubeless percutaneous nephrolithotomy: a systematic review and meta-analysis. *Urol Res* 2011; 39:401-410. doi: 10.1007/s00240-010-0355-5.
22. *Isac W, Rizkala E, Liu X, Noble M, Monga M.* Tubeless percutaneous nephrolithotomy: outcomes with expanded indications. *Int Braz J Urol Off J Braz Soc Urol* 2014; 40:204.
23. *Bellman GC, Davidoff R, Candela J, Gerspach J, Kurtz S, Stout L.* Tubeless percutaneous renal surgery. *J Urol* 1997; 157: 1578-1582. Available from: <https://pubmed.ncbi.nlm.nih.gov/9112480/>.
24. *Borges CF, Fregonesi A, Silva DC, Sasse AD.* Systematic review and meta-analysis of nephrostomy placement versus tubeless percutaneous nephrolithotomy. *J Endourol*. 2010; 24: 1739-1746. doi: 10.1089/end.2010.0231.
25. *Chen Z-J, Yan Y-J, Zhou J-J.* Comparison of tubeless percutaneous nephrolithotomy and standard percutaneous nephrolithotomy for kidney stones: A meta-analysis of randomized trials. *Asian J Surg* 2020; 43(1):60-68. doi: 10.1016/j.asjsur.2019.01.016.
26. *Iqbal N, Assad S, Hussain I, Hassan Y, Khan H, Armaghan M, et al.* Comparison of outcome of tubed versus tubeless percutaneous nephrolithotomy in children: A single-center study. *Turk J Urol* 2018; 44(1): 56-61. doi: 10.5152/tud.2018.19616.
27. *Samad L, Zaidi Z.* Tubed vs Tubeless PCNL in children. *J Pak Med Assoc* 2012; 62 (9): 892-896. Available from: <https://pubmed.ncbi.nlm.nih.gov/23139970/>.
28. *Shah H, Khandkar A, Sodha H.* Tubeless percutaneous nephrolithotomy: 3 years of experience with 454 patients. *BJU Int* 2009; 104:840–846. doi: 10.1111/j.1464-410X.2009.08496.x.
29. *Al-Toma RR.* Safety and efficacy of percutaneous nephrolithotomy in patients with a single functioning kidney compared to patients with bilateral functioning kidneys. *F1000Research* 2019, 8:742. doi: 10.12688/f1000research.19259.1.
30. *Rashid AO, Amin SH, Al Kadum MA, Mohammed SK, Buchholz N.* Mini-Percutaneous Nephrolithotomy for Complex Staghorn Stones in Children. *Urol Int* 2019; 102(3):356-359. doi: 10.1159/000499491.
31. *Balandi S, Ibrahim I.* Tubeless versus standard percutaneous nephrolithotomy at Duhok province, Kurdistan, Iraq. *Duhok Medical Journal* 2018; 11(1): 49-59. doi: 10.31386/dmj.2017.11.6.
32. *aal-Toma RRJ.* Comparative study of the outcome of tubed versus tubeless percutaneous nephrolithotomy. *Ukrainian Journal of Nephrology and Dialysis* 2019; 2(62): 18–23. doi: 10.31450/ukrjnd.2(62).2019.03.
33. *Armitage JN, Irving SO, Burgess NA.* British Association of Urological Surgeons Section of Endourology: Percutaneous nephrolithotomy in the United Kingdom: results of a prospective data registry. *Eur Urol* 2012; 61: 1188-1193. doi: 10.1016/j.eururo.2012.01.003.

34. Nakamon T, Kitirattrakarn P, Lojanapiwat B. Outcomes of percutaneous nephrolithotomy: comparison of elderly and younger patients. *Int Braz J Urol* 2013; 39(5):692-700; discussion 701. doi: 10.1590/S1677-5538.IBJU.2013.05.12.
35. Abdelrahman I, Ebeid AI, Elhelaly HA, Selmy GI, Galal H. Predicting surgical outcome of pediatric percutaneous nephrolithotomy. *Annals of Pediatric Surgery* 2018, 14:174-177. doi: 10.1097/01.XPS.0000530171.06705.20.
36. Pelit ES, Kati B, Çanakci C, Sağır S, Çiftçi H. Outcomes of miniaturized percutaneous nephrolithotomy in infants: single centre experience. *Int Braz J Urol* 2017; 43(5):932-938. doi: 10.1590/S1677-5538.IBJU.2016.0629.
37. Kagalkar S, Agarwal SK. Percutaneous nephrolithotomy in the pediatric age group: a study from North Karnataka. *Int Surg J* 2020; 7:117-121. doi: 10.18203/2349-2902.isj20195955.
38. Lu P, Song R, Yu Y, Yang J, Qi K, Tao R, et al. Clinical efficacy of percutaneous nephrolithotomy versus retrograde intrarenal surgery for pediatric kidney urolithiasis. *Medicine* 2017; 96 (43): e8346. doi: 10.1097/MD.0000000000008346.
39. Amer T, Ahmed K, Bultitude M, Khan S, Kumar P, De Rosa A, Khan M, S, Hegarty N. Standard versus Tubeless Percutaneous Nephrolithotomy: A Systematic Review. *Urol Int* 2012; 88:373-382. doi: 10.1159/000336145.
40. Abbott JE, Deem SG, Mosley N, Tan G, Kumar N, Davalos JG. Are we fearful of tubeless percutaneous nephrolithotomy? Assessing the need for tube drainage following percutaneous nephrolithotomy. *Urol Ann* 2016; 8(1):70-75. doi: 10.4103/0974-7796.162214.
41. Keshavamurthy R, Kumar S, Karthikeyan VS, Mallya A, Nelivigi GG. Tubeless Pediatric Percutaneous Nephrolithotomy: Assessment of Feasibility and Safety. *J Indian Assoc Pediatr Surg* 2018; 23(1):16-21. doi: 10.4103/jiaps.JIAPS_22_17.
42. Lee JY, Jeh SU, Kim MD, Kang DH, Kwon JK, Ham WS, et al. Intraoperative and postoperative feasibility and safety of total tubeless, tubeless, small-bore tube, and standard percutaneous nephrolithotomy: a systematic review and network meta-analysis of 16 randomized controlled trials. *BMC Urol* 2017; 17(1):48. doi: 10.1186/s12894-017-0239-x
43. Moosanejad N, Firouzian A, Hashemi SA, Bahari M, Fazli M. Comparison of totally tubeless percutaneous nephrolithotomy and standard percutaneous nephrolithotomy for kidney stones: a randomized, clinical trial. *Braz J Med Biol Res* 2016; 49(4):e4878. doi: 10.1590/1414-431X20154878.
44. Xun Y, Wang Q, Hu H, Lu Y, Zhang J, Qin B, et al. Tubeless versus standard percutaneous nephrolithotomy: an update meta-analysis. *BMC Urol* 2017; 17(1):102. doi: 10.1186/s12894-017-0295-2.
45. Lojanapiwat B, Prasopsuk S. Upper-pole access for percutaneous nephrolithotomy: comparison of supracostal and infracostal approaches. *J Endourol* 2006; 20(7):491-494. doi: 10.1089/end.2006.20.491.