Research Article

Determinants of Partial Stone Clearance after Mini-PCNL in the Pediatric Population

Farmanullah[*,1], Javed Altaf Jat[2], Muhammad Murtaza Azad[3], Syed Daniyal Raza[4]

[1]*Department of Paediatric Urology, Sindh Institute of Urology and Transplantation (SIUT), Karachi, Pakistan.*
[2]*Department of Urology, Lahore University of Management Sciences (LUMS), Lahore, Pakistan.*
[3]*Department of Urology, SHED Hospital, Karachi, Pakistan.*
[4]*Department of Urology, Tabba Kidney Institute, Karachi, Pakistan.*

Abstract: Background: The prevalence of renal stones in pediatric population is increasing in Pakistan, to minimize the adverse outcomes of renal stone disease accurate diagnosis and proper management is necessary.

Objective: This study aim to evaluate the risk factors of partial stone clearance after mini-PCNL in the pediatric population of Pakistan.

Materials and Methods: This is a retrospective, cross-sectional study conducted at Godhra Hospital, Karachi, during 2021, patients diagnosed with single or multiple renal stones requiring PCNL were enrolled in the study, Guy's stone score was used as a prediction method for complete clearance. SPSS version 22 was used to analyze the data, chi-square test was used to assess the significance of the data keeping a p-value ≤0.05 as significant. The risk estimation was analyzed with the help of the odds ratio test.

Result: A total of 234 participants with mean age of 6.4 ± 4.8 years were enrolled. Stone clearance was reported 203 (86.7%) and 31 (13.2%) residual fragments. 09 (3.8%) out of the residual stone group needed intervention for complete clearance while the remaining were reported as stone free after 4 weeks with METs. The mean residual stone size was 0.7 ± 0.3, upon assessing the determinants maximum patients had Staghorn (> 4) cms stone size with 7 (2.9%) of patients out of 13 (5.5%). The odds of having partial clearance were reportedly positive with 2.34 in staghorn ≥ 4cms stone size and 1.62 in Grade IV Guy's stone score.

Conclusion: Stone size ≥ 4.0 cm and staghorn calculi present in all calyces are independent risk factors for partial stone clearance after Mini-PCNL.

Keywords: Pediatric urolithiasis, Mini-PCNL, Partial stone clearance, Staghorn calculi, GUY'S stone score, Patients.

INTRODUCTION

The incident rate of renal stones in pediatric population of Pakistan has been evaluated in past two decades and results indicated an alarming rise in prevalence from 5%-15% approximately, along with a major shift of management strategies from open surgeries to extracorporeal shockwave lithotripsy, percutaneous nephrolithotomy to laparoscopic nephrolithotomy, mini percutaneous nephrolithotomy (PCNL), micro PCNL and advanced lithotripsy techniques from pneumatic to laser and Master Litho-Clast® [1-3]. The recommendations for treating kidney stone disease in children frequently mirror those for treating kidney stone disease in adults [4]. The previous 16 years have seen a rise in pediatric stone disease intervention, increasing by three folds in the last ten years. European Association of Urology (EAU) guidelines indicated PCNL as the gold treatment of staghorn renal calculi, multiple renal stones, and large renal stones (> 1.5 cm) in pediatric populations. Recent years have seen an increase in the acceptance of miniature PCNL as a means of peri-operative morbidity reduction and high SFR delivery [5-7]. Applying smaller sheaths implies that the renal parenchyma will suffer less damage the smaller the PCNL tract. With no change in therapeutic efficacy, there would be less related morbidity, less intraoperative blood loss and a requirement for blood transfusions, less postoperative analgesia needed, and shorter hospital stays [8]. Its potential advantage to traditional PCNL in terms of safety and efficacy, however, is still up for debate. Stone-free rate prediction and post-operative complications were always a concern for urologists, especially in pediatric patients, the Guy's stone score was used to predict success rates of PCNL and assess the outcomes to avoid any unpleasant complication [9]. The broad application of a standardized stone scoring system is extremely beneficial for patient counseling, professional judgment, and result evaluation, in addition to enhancing academic reporting. However, there isn't a stone score system that is widely acknowledged for predicting SFR and problems following PCNL [10]. Most common and postoperative complications after PCNL are categorized as longer hospital stay, particle stone clearance, elevated post-operative pain, sepsis, need to re-do procedures, increased hemoglobin drop, need for blood transfusion, and longer operative duration indicating longer anesthesia duration and associated issues, need for auxiliary procedures were considered as another risk of partial stone clearance [7, 8, 11]. This

*Address correspondence to this author at the Department of Paediatric Urology, Sindh Institute of Urology and Transplantation (SIUT), Karachi, Pakistan. Email: farmanullah87@yahoo.com

study aims to provide a comprehensive evaluation of contributing factors in partial stone clearance after PCNL in the pediatric population of Pakistan.

MATERIALS AND METHODS

This is a retrospective, cross-sectional study conducted in Godhra Hospital, located in Karachi. Patients presented in the Emergency room or outpatient departments of both institutes and diagnosed with suspicious renal stones and had their radiological investigations done, Ultrasound KUB, X-ray KUB, and/or CT KUB separately or in rare cases in combination, diagnosed with renal stones and prescribed for mini PCNL (Amplatz sheath size ≤18 fr) after complete clinical and radiological investigations were enrolled in the study. Patients with impaired renal function, low eGFR, and higher serum creatinine were excluded from the study.

Complete demographic details, family history of renal disorders, and previous history of renal issues were documented. Stone characteristics including stone size, stone site, stone location, hydronephrosis degree, Guy's stone score, Pre-operative and Postoperative laboratory investigation, and Postoperative complications were documented, Guy's stone score was determined with the help of standardized Guy's score definition of grade I, II, III and IV after radiological investigations. The Guy Stone Score (GSS) is an easy-to-use and trustworthy method of success rate prediction GSS is primarily used to predict the success rate after PCNL in Intravenous Urography (IVU) and Kidney, Ureter, and Bladder (KUB) films (Table **1**).

Table 1. Guy's Stone Score Description.

Definitions of Guy's Stone Score	
Guy's Score	**Description**
Grade I	Solitary renal stone in the mid or lower pole or in the renal pelvis in a kidney with normal anatomy.
Grade II	Solitary renal stone in the upper pole or multiple stones in a patient with simple kidney anatomy; a solitary stone in a patient with abnormal anatomy, such as an abnormal collecting system, or in a patient with an ileal conduit.
Grade III	Multiple renal stones in a patient with abnormal anatomy or stones in a calyceal diverticulum or a partial staghorn stone, defined as a stone involving the renal pelvis and at least two calyces.
Grade IV	Complete staghorn calculus [defined as calices and the pelvis occupied by stones] or any stone in patient with spina bifida or a spinal injury.

The size, number, and placement of access points, the duration of the procedure, the patient's stone-free status (as determined by fluoroscopy and endoscopy), the Hb decrease, transfusions, and complications (according to hospital stay, auxiliary procedures, and Clavien classification. Children were evaluated with renal ultrasonography and X-ray KUB after 4 weeks of procedure. The remaining particles less than 4 mm were considered to have a stone-free state.

STATISTICAL ANALYSIS

Statistical Package of social sciences (SPSS) version 22 was used to enter and analyze the data, for independent variables like age and gender mean, standard deviation frequencies, and percentages were calculated. The chi-square test was used to assess data significance, keeping the p-value ≤ 0.05 as significant. Estimation of the risk of getting partial clearance after PCNL was analyzed with the help of a risk estimation (OR) test keeping 1.0 as a positive value and the Confidence interval as 95%.

RESULT

A total of 234 participants with renal stone diagnosis, undergoing mini PCNL were enrolled in the study, mean age of participants was 6.4 ± 4.8 years with a range of 2 -15 years, while the mean weight was 32.7 ± 12.3 kgs, with a range of 14 – 39 kgs. Gender distribution indicated male dominance with 127 (54.2%) of the total population in the study. The overall stone clearance was reported as 203 (86.7%) and 31 (13.2%) reported residual fragments. 09 (3.8%) out of the residual stone group needed intervention for complete clearance while the remaining were reported as stone free after 4 weeks with METs. Pre-operative stone characteristics were documented, results indicated maximum stones were on the left kidney with 108 (46.1%), followed by 83 (35.4%) right-sided stones, only 43 (18.3%) patients had bilateral stones, while the p-value of the stone side was 0.874. Stone size was categorized into 04 groups according to the size starting from 1cm – 2 cm in group 1, 2.1-3cms in group 2, 3.1-4 cms in group 3, and > 4 cms stone size in group 4 with the frequency of 60 (25.6%), 132 (56.4%), 29 (12.3%) and 13 (5.5%) respectively, the p-value of stone size within all groups was insignificant and 0.414. 147 (62.8%) patients had single stones, while 87(37.1%) had bilateral stones with p-value of 0.078. Guy's stone score was categorized within Grade I, II, III, and IV with frequencies of 92 (39.3%), 71 (30.3%), 58 (24.7%), and 13 (5.5%) respectively. The p-value was estimated as insignificant and 0.737 (Table **2**).

Table 2. Stone characteristics of study participants

Variables		N (%)	P-Value
Stone Side	Right	83 (35.4%)	0.874
	Left	108 (46.1%)	
	Bilateral	43 (18.3%)	
Stone Size	1.0-2.0 cms	60 (25.6%)	0.414
	2.1-3.0 cms	132 (56.4%)	
	3.1-4.0 cms	29 (12.3%)	
	Staghorn ≥ 4.0 cms	13 (5.5%)	
Stone Number	Single	147 (62.8%)	0.078
	Multiple	87 (37.1%)	

Continued

Continued

Guy's Stone Score	Grade I	92 (39.3%)	0.737
	Grade II	71 (30.3%)	
	Grade III	58 (24.7%)	
	Grade IV	13 (5.5%)	

187 (79.9%) patients had a subcostal approach while 31(13.2%) patients had a Supracostal approach. Only 16 (6.8%) patients had a double calyceal approach. 29 (12.3%) patients had tubeless PCNL while the remaining 205 (87.6%) had nephrostomy.

Upon assessing the immediate post-operative x-ray 207 (88.4%) patients reported stone clearance with no residual fragmentation while 27 (11.5%) had mild fullness and indicated as residual debris. While follow-up investigation revealed 31 (13.2%) residual stones. Post-operative complications were documented as sepsis in 11(4.7%) patients, redo PCNL 2 (0.8%), and the need for ESWL was identified in 7 (2.9%) while 9 (3.8%) surgery was converted to open due to intraoperative bleeding. fever was reported in 43 (18.3%), Respiratory issues in 4 (1.7%), Pelvicalyceal injury was reported in 7 (2.9%), late bleeding in 6 (2.5%) while perioperative bleeding in 9 (3.8%) (Fig **1**).

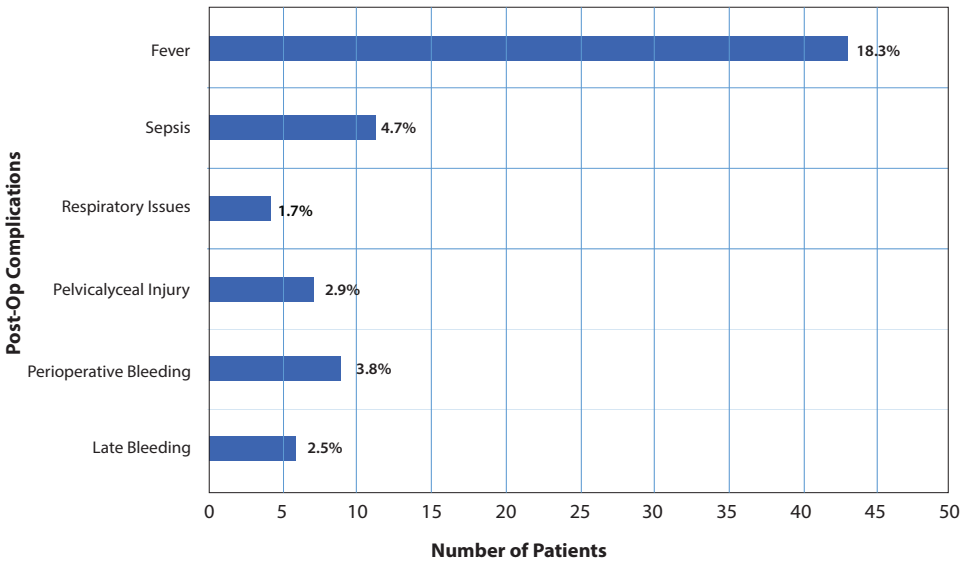

Fig. (1). Post-operative Complications in Study Participants.

Mean operative time was measured as 83.7 ± 17.8 mins, while mean hospital stay was 2.1 ± 1.7 days. The hemoglobin drop was measured after analyzing pre-operative and post-operative hemoglobin quantity, the mean value was 1.8 ± 0.9 g/dL. The mean stone size was measured as 2.7 ± 1.2 cms and the residual stone size was 0.7 ± 0.3 (Table **3**).

Table 3. Post-operative details of operative time, hospital stay, and residual stones.

Variables	Mean ± St. dev.
Operative time (mins)	83.7 ± 17.8
Hospital stay (days)	2.1 ± 1.7
Hemoglobin drop (g/dL)	1.8 ± 0.9
Stone size (cm)	2.7 ± 1.2
Residual stone (cm)	0.7 ± 0.3

Post-operative complications were determined with the help of Clavien-Dindo classification and grades I, II, III-A & III-B were categorized only with 21 (44%), 18 (37%), 7 (15%) and 2 (4%) respectively (Fig. **2**).

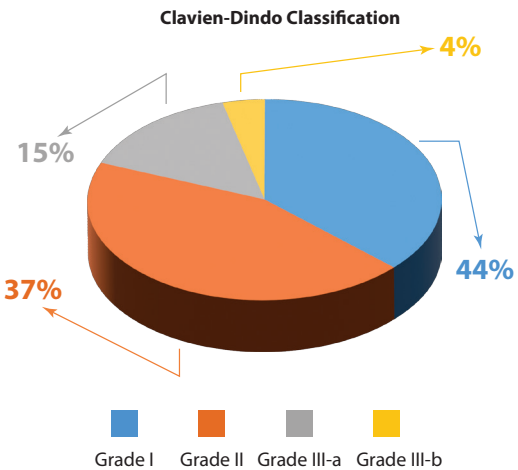

Fig. (2). Clavien-Dindo Classification in Study Participants.

The last follow-up of patients was scheduled for 4th week after operation, X-ray KUB or Ultrasound KUB was used to finalize the presence of residual stones. Partial clearance was reported in 31 (13.2%), upon assessing the determinants maximum patients had Staghorn (> 4) cms stone size with 7 (2.9%) of patients out of 13 (5.5%). Similarly, patients with multiple stones, Grade I, II, III, and IV also reportedly had partial clearances. The odds

of having partial clearance were reportedly positive with 2.34 in staghorn ≥ 4cms stone size and 1.62 in Grade IV Guy's stone score, the CI 95% was 1.31-4.61 and 0.57-2.24 respectively (Table **4**).

Table 4. Determinants Estimation of Partial Clearance.

Variables	n (%)	Partial clearance n (%)	OR	CI 95%
Multiple stones	87 (37.1%)	4 (1.7%)	0.41	0.01-1.20
Stone size ≥ 4.0 cms	13 (5.5%)	7 (2.9%)	2.34	1.31-4.61
Guy's Score				
Grade I	92 (39.3%)	6 (2.5%)	0.92	0.37-1.18
Grade II	71 (30.3%)	5 (2.1%)	0.37	0.04-0.91
Grade III	58 (24.7%)	2 (0.8%)	0.09	0.01-0.73
Grade IV	13 (5.5%)	7 (2.9%)	1.62	0.57-2.24

DISCUSSION

Urolithiasis prevalence in the pediatric population has been enhanced especially in Asian countries including Pakistan, India, Bangladesh, and Afghanistan ranging from 30%-45% in developing countries [12, 13]. The main focus of urologists is to provide complete stone clearance with minimum radiation exposure, anesthesia duration, hospitalization duration, operative time, and post-operative complications. Non-invasive techniques such as extracorporeal shockwave lithotripsy (ESWL) and Medical explosive therapy (METs) are good options for treating smaller stone sizes ranging from 0.1 cm-0.8 cm [14]. However, ESWL and METs require thorough investigations and diagnostic accuracy to evaluate the success rates of treatment, invasive treatments including retrograde intrarenal surgery (RIRS), Ureteroscopy (URS), percutaneous nephrolithotomy (PCNL), mini PCNL and micro PCNL reported great stone-free rates [15-17]. This study aimed to assess the determinants of partial stone clearance after mini PCNL in the pediatric population, the overall stone clearance was reported as 225/234 (96.1%) on the fourth week's radiological investigation while 9 (3.8%) residual stones requiring intervention. A study from India reported similar results of 96.3% stone clearance in a sample size of 80 on post-operative X-ray KUB [18]. The mean age of the study population was similar to another study conducted in India, where the mean age value was 8.2 ± 3.7 years, the mean age of another study conducted in UAE reported similar mean age and gender distribution [19]. The mean operative duration was similar to our study, ranging from 50-120 mins, slight difference in our mean operative time was due to 9(3.8%) cases of conversion to open Lithotomy [20]. The pelvicalyceal injury was reported as a severe postoperative complication in 7 (2.9%), followed by perioperative bleeding leading to converted to open in 9 (3.8%) patients, fever was reported in 43 (18.3%) while only 11 (4.7%) had a high-grade fever. Reported Guy's stone score indicated categorization of our study participants within Grades I to Grade III-B, the results were similar as parts IV and V were reported less than grades I-III. Similarly, Clavien-Dindo classification indicated Grade I, II, III, and IV with 92 (39.3%), 71 (30.3%), 58 (24.7%), and 13 (5.5%) respectively which was similar to another study conducted in India [21-23]. The major independent determinant for partial clearance was ≥ 4 cm of stone size, which was previously been reported in other studies, the staghorn calculi with measurements of ≥ 4 cms are difficult to clear in a single sitting especially in pediatric populations without compromising the risk of postoperative complications such as perioperative bleeding, conversion to open and need for blood transfusion [24-27]. However, grade IV of Guy's stone score was another independent determinant of partial stone clearance endorsing the fact that staghorn calculi in all calyces are difficult to remove in a single sitting, reported in previous studies [28-33].

CONCLUSION

Our study concluded that stone size ≥ 4.0 cm and staghorn calculi present in all calyces are independent risk factors for partial stone clearance after Mini-PCNL, however, gender, history of stone disease, previous stone removal surgery, and/or multiple stones presence was reportedly not proved as determinant of partial clearance.

AUTHORS' CONTRIBUTION

- **Farmanullah**: Objective, Data analysis.
- **Javed Altaf**: Result interpretation, Statistical analysis.
- **Murtaza Azad**: Data collection.
- **Danial Raza**: Write-up, Ethical consideration.

CONFLICT OF INTEREST

Declared none.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES

[1] Zhao Z, Cui Z, Zeng T, Wan SP, Zeng G. Comparison of 1-stage with 2-stage multiple-tracts mini-percutaneous nephrolithotomy for the treatment of staghorn stones: A matched cohorts analysis. Urology 2016; 87: 46-51.

[2] Khadgi S, El-Nahas AR, El-Shazly M, Al-Terki A. Comparison of standard-and mini-percutaneous nephrolithotomy for staghorn stones. Arab J Urol 2021; 19(2): 147-51.

[3] Rashid AO, Amin SH, Kadum A, Abed M, Mohammed SK, Buchholz N. Mini-percutaneous nephrolithotomy for complex staghorn stones in children. Urol Int 2019; 102(3): 356-9.

[4] Mahmood SN, Aziz BO, Tawfeeq HM, Fakhralddin SS. Mini–versus standard percutaneous nephrolithotomy for treatment of pediatric renal stones: is smaller enough?. J Pediatr Urol 2019; 15(6): 664-e1.

[5] Aarthy P, Thangarasu M, Prakash JS, *et al*. Safety and efficacy of mini-percutaneous nephrolithotomy as daycare procedure: A prospective observational study. Afr J Urol 2021; 27(1): 1-6.

[6] Jones P, Hawary A, Beck R, Somani BK. Role of mini-percutaneous nephrolithotomy in the management of pediatric stone disease: A systematic review of literature. J Endourol 2021; 35(5): 728-35.

[7] Tzelves L, Türk C, Skolarikos A. European association of urology urolithiasis guidelines: Where are we going?. Eur Urol Focus 2021; 7(1): 34-8.

[8] Diri A, Diri B. Management of staghorn renal stones. Renal Failure 2018; 40(1): 357-62.

[9] Rehman OF, Khan A, Harvey H, *et al*. Mini PCNL: A viable single stage treatment for pediatric nephrolithiasis in resource limited countries. J Pediatr Urol 2021; 17(3): 388-e1.

[10] Abdelhafez MF, Amend B, Bedke J, *et al*. Minimally invasive percutaneous nephrolithotomy: A comparative study of the management of small and large renal stones. Urology 2013; 81(2): 241-5.

[11] Ganpule AP, Vijayakumar M, Malpani A, Desai MR. Percutaneous nephrolithotomy (PCNL) a critical review. Int J Surg 2016; 36: 660-4.

[12] Trinchieri A. Epidemiology of urolithiasis. Arch Ital Urol Androl 1996; 68(4): 203-49.

[13] Holman E, Khan AM, Flasko T, Toth C, Salah MA. Endoscopic management of pediatric urolithiasis in a developing country. Urology 2004; 63(1): 159-62.

[14] Shahat AA, Abonnoor AE, Allaham SM, Abdel-Moneim AM, El-Anany FG, Abdelkawi IF. Critical application of adult nephrolithometric scoring systems to children undergoing mini-percutaneous nephrolithotomy. J Endourol 2020; 34(9): 924-31.

[15] Abdelhafez MF, Bedke J, Amend B, *et al*. Minimally invasive percutaneous nephrolitholapaxy (PCNL) as an effective and safe procedure for large renal stones. BJU Int 2012; 110(11c): E1022-6.

[16] Al-Kohlany KM, Shokeir AA, Mosbah A, *et al*. Treatment of complete staghorn stones: a prospective randomized comparison of open surgery versus percutaneous nephrolithotomy. J Urol 2005; 173(2): 469-73.

[17] Lin CH, Lin YC, Chiang HC, *et al*. Totally tubeless single access tract mini-percutaneous nephrolithotripsy in treatment of large burden> 2-cm and/or complex renal stones: A case series of 62 patients. BMC Urol 2022; 22(1): 1-6.

[18] Kumar J, Mandhani A, Srivastava A, Kapoor R, Ansari MS. Pediatric urolithiasis: Experience from a tertiary referral center. J Pediatr Urol 2013; 9(6): 825-30.

[19] Shahait M, Farkouh AA, Mucksavage P, Somani B. Outcome of mini-PCNL under loco-regional anesthesia: Outcomes of a systematic review. Curr Urol Rep 2023; 24(9): 417-26.

[20] Kang M, Son H, Jeong H, Cho MC, Cho SY. Clearance rates of residual stone fragments and dusts after endoscopic lithotripsy procedures using a holmium laser: 2-year follow-up results. World J Urol 2016; 34: 1591-7.

[21] Brohi IB, Bajwa IA, Ali F, *et al*. Clinical characteristics and patient outcomes of urolithiasis and ureteral stones in a pediatric population. Pakistan J Med Health Sci 2022; 16(09): 268-70.

[22] Kapoor R, Solanki F, Singhania P, Andankar M, Pathak HR. Safety and efficacy of percutaneous nephrolithotomy in the pediatric population. J Endourol 2008; 22(4): 637-40.

[23] Kumar R, Anand A, Saxena V, Seth A, Dogra PN, Gupta NP. Safety and efficacy of PCNL for management of staghorn calculi in pediatric patients. Journal of Pediatr Urol 2011; 7(3): 248-51.

[24] Gao X, Fang Z, Lu C, Shen R, Dong H, Sun Y. Management of staghorn stones in special situations. Asian J Urol 2020; 7(2): 130-8.

[25] Scarcella S, Tiroli M, Torino G, Mariscoli F, Cobellis G, Galosi AB. Combined treatment of ureteropelvic junction obstruction and renal calculi with robot-assisted laparoscopic pyeloplasty and laser lithotripsy in children: Case report and non-systematic review of the literature. Int J Med Robot 2021; 17(3): e2246.

[26] Zaheer M, Rauf A, Fazal-Ur-Rehman KH, Atta-Ur-Rehman R, Rasool S, Shokat Z. Efficacy of Micro PCNL for renal stones in pediatric age group. PJMHS 2021; 15(9): 2384-6.

[27] Alur V, Praveen VP, Kumar H, Deka S, Chandolia B. Prevalence of metabolic abnormalities in patients having the risk of recurrent renal stones. J Appl Sci Clin Pract 2023; 4(1): 13.

[28] Ramya K, Krishnamurthy S, Manikandan R, Sivamurukan P, Naredi BK, Karunakar P. Metabolic and clinical characteristics of children with urolithiasis from southern India. Indian J Pediatrics 2021; 88: 345-50.

[29] Kagalkar S, Agarwal SK. Percutaneous nephrolithotomy in the pediatric age group: A study from North Karnataka. Int Surg J 2020; 7(1): 117-21.

[30] Khadgi S, Darrad M, El-Nahas AR, Abdullatif AT. Tubeless mini-percutaneous nephrolithotomy for renal stones larger than 20 mm. Indian J Urol 2021; 37(1): 54.

[31] Li H, Yin Y, Nie M. Efficacy and safety of super-mini percutaneous nephrolithotomy in the treatment of urinary calculi: A systematic review and meta-analysis. BMC Urol 2023; 23(1): 1-8.

[32] Mahmoud MA, Shawki AS, Abdallah HM, Mostafa D, Elawady H, Samir M. Use of retrograde intrarenal surgery (RIRS) compared with mini-percutaneous nephrolithotomy (mini-PCNL) in pediatric kidney stones. World J Urol 2022; 40(12): 3083-9.

[33] Bukhari H, Muhammad I, Muhammad S, Muhammad N, Iqbal M, Ahmed R, Ullah S. The prevalence of neglected renal stone among patients presented with acute kidney injury to a tertiary care hospital. J Med Sci 2023; 31(01): 17-20.

Received: July 14, 2023 Revised: December 05, 2023 Accepted: December 05, 2023