The Effectiveness of Supine Mini-PCNL in a Single Center: First One Hundred Cases

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ABSTRACT

Introduction and Objectives. PCNL (percutaneous nephrolithotomy) is the gold standard in the treatment of large, complex (particularly recommended for staghorn calculi) renal stones, or when these are associated with anatomical abnormalities or resistant to other minimally invasive procedures. Mini-PCNL, designed to reduce the perioperative complications, showed that it is not only a miniaturization but also a different method to remove the stones, as the fragments come out of the calyceal system only using the vortex effect. Initially described in prone position, these percutaneous procedures were adopted later in supine position (Valdivia position and its modified variants), given its advantages like more comfortable patient positioning, shorter operative time, lower intrarenal pressure and simultaneous retrograde ureteroscopic access. The aim of the study was to assess the outcomes of supine mini-PCNL into a center of tradition for standard prone PCNL.

Materials and Methods. One hundred patients underwent mini-PCNL in supine position (Valdivia and Galdakao modified Giusti). In 93 cases the indication was renal urolithiasis and for the other 7 cases this technique was used for treatment of complications in patients with urinary diversion. In all cases we used combined fluoroscopic and ultrasound guidance. We used a 12 Fr nephroscope and 15/16Fr access sheaths. All procedures finished with placing a nephrostomy tube. Ten cases needed Double J stenting.

Results. The median patients age was 53 years (range 27-73 years). The median operative time was 60 minutes (range 30-150 minutes). Mean postoperative hospital stay was 2.4 days. The stone free rate was 82% evaluated by abdominopelvic computed tomography. The renal pelvis injury was encountered in two cases successfully managed by Double J stenting. Postoperative hemorrhage didn't require blood transfusion or any other surgical intervention. Two other cases had CLAVIEN II complication (fever and sepsis, respectively).

Conclusions. The findings of this study demonstrated that supine mini-PCNL is an effective and safe technique for the management of renal lithiasis in our department.

Key-words: mini percutaneous nephrolithotomy, percutaneous nephrolithotomy, stone-free rate, supine position, urolithiasis

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INTRODUCTION AND OBJECTIVES

Urinary lithiasis is a prevalent condition affecting millions of individuals worldwide. It results from the crystallization of urinary solutes, most commonly calcium, oxalate, and uric acid, leading to the formation of stones in the urinary tract. Most frequent incriminated risk factors include dietary habits, genetic predisposition, metabolic disorders, and inadequate fluid intake [1]. The prevalence of kidney stones is highly variable worldwide with rates ranging from 7% to 13% in North America, 5–9% in Europe, and 1–5% in Asia [1]. A systematic review of 21 studies, published between 1976 and 2011, found that the median five-year recurrence rate for individuals experiencing their first kidney stone was 26% [2].

PCNL (percutaneous nephrolithotomy) is the gold standard in the treatment of renal lithiasis in cases where stones are large (>20 mm), complex (particularly recommended for staghorn calculi), associated with anatomical abnormalities or resistant to other minimally invasive procedures such as extracorporeal shock wave lithotripsy (ESWL) or ureteroscopy. The procedure offers the highest stone-free rates of the mentioned minimally invasive procedures and is a valuable tool in the urologist's armamentarium for managing challenging stone cases [3].

However, standard PCNL with large percutaneous tract (24-30 Fr) can result in serious postoperative complications: hemorrhage requiring blood transfusion (7%), sepsis (0.5%), adjacent organ injury (0.4%), and even death (0.05%) [4]. Mini-PCNL (12–20 F), originally developed for pediatric patients, was later adopted for the general population to minimize morbidity [5,6]. Both standard and mini-PCNL are cost efficient procedures, because the nephroscopes and the dilatation sheets are more resistant and cheaper in comparison to the instruments needed for ureteroscopy or ESWL [7,8,9].

The ongoing experience with the mini-PCNL showed that this technique is not only a miniaturization but also a different method to remove the stones, as the fragments come out of the calyceal system only by means of the irrigation flow without any further need of forceps or baskets. Initially described in prone position, these percutaneous procedures were adopted later in supine position (Valdivia position and its modified variants), given its advantages like more comfortable patient positioning, shorter operative time, lower intrarenal pressure and simultaneous ureteroscopic access [10,11,12].
The aim of the study was to assess the outcomes of supine mini-PCNL into a center of tradition for standard prone PCNL.

MATERIALS AND METHODS

We retrospectively included in our study 100 consecutive cases who underwent mini-PCNL in supine position between November 2022 and April 2024 in Urology Department of Bihor Emergency Clinical County Hospital (Oradea, Romania). In 93 cases the indication was renal lithiasis, while in the other seven cases the procedure was used for management of complications of urinary diversion (ascended or calcified stents). In all cases, the imaging evaluation was performed by abdominopelvic Computed Tomography to establish the volume of stone, the particular anatomy of the pyelocaliceal system, other anatomic variants (like retrorenal colon).

We demanded preoperative urine culture in all patients. If it was positive, the urinary infection was treated preoperatively according to the antibiogram. If negative, empiric antibiotic prophylaxis with third generation cephalosporin (or aminoglycoside, in case of allergy) was begun at least one hour before procedure. Antithrombotic therapy was interrupted according the international guidelines [13]. Most of the procedures were performed in spinal anaesthesia, only in patients with contraindication or refuse this type of anaesthesia a general anaesthesia was used.

Given the conformation of our operating room (limited space with limited mobility of the endoscopy tower, C-arm, anaesthesia workstation, et cetera), the positioning of the patient is different for the right versus left side. For left mini-PCNL, we placed the patient in Giusti's position (Giusti modification of the Valdivia-Galdakao position – Figure 1), without repositioning after ureteral

catheter placement. For right mini-PCNL, we initially put the patient in low lithotomy position for the ureteral catheter placement, then the patient is repositioned in Valdivia position and the surgical table rotated 180 degrees.

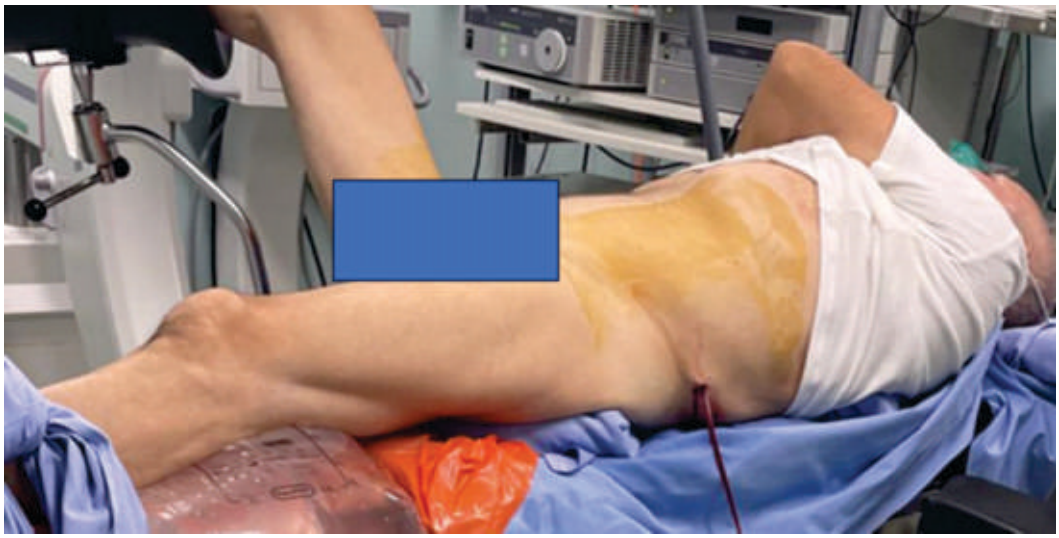


Figure 1. Giusti modification of the Valdivia-Galdakao position

The 6 Fr ureteral catheter was placed in all cases under fluoroscopic guidance with a rigid cystoscope, then secured along a Foley urethrovesical catheter.

The puncture was performed under ultrasound control, then the position of the needle is controlled and modified as needed under fluoroscopic control. A Lunderquist guidewire (from nephrostomy kit (Balton - Warsaw, Poland)) is placed, then sequential dilation is performed under fluoroscopic guidance (Figure 2), up to 16 Fr. We used a 12 Fr nephroscope and 15/16 Fr access sheaths MIP-M (Karl Storz - Tuttlingen, Germany) – Figure 3. A 600 µm reusable laser fiber connected to 15 W low-power Holmium LASER (Karl Storz - Tuttlingen, Germany) was used for lithotripsy. We usually set up the laser on fragmentation mode, with short pulse duration, energy at 2 J and the frequency at 10 Hz. The fragments were retrieved in most of the cases based on specific vortex effect, or using a grasper or different types of baskets. For complex calculi, additional percutaneous tracts were performed.

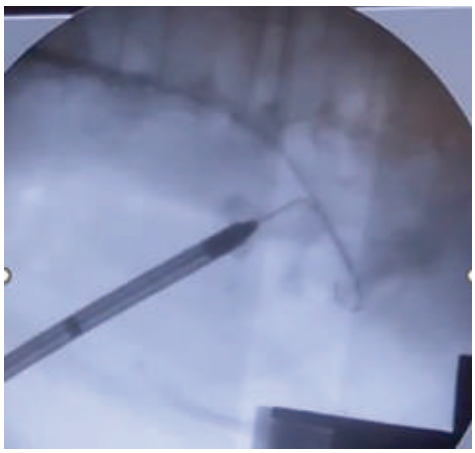


Figure 2. Placement of the access sheath under fluoroscopic control

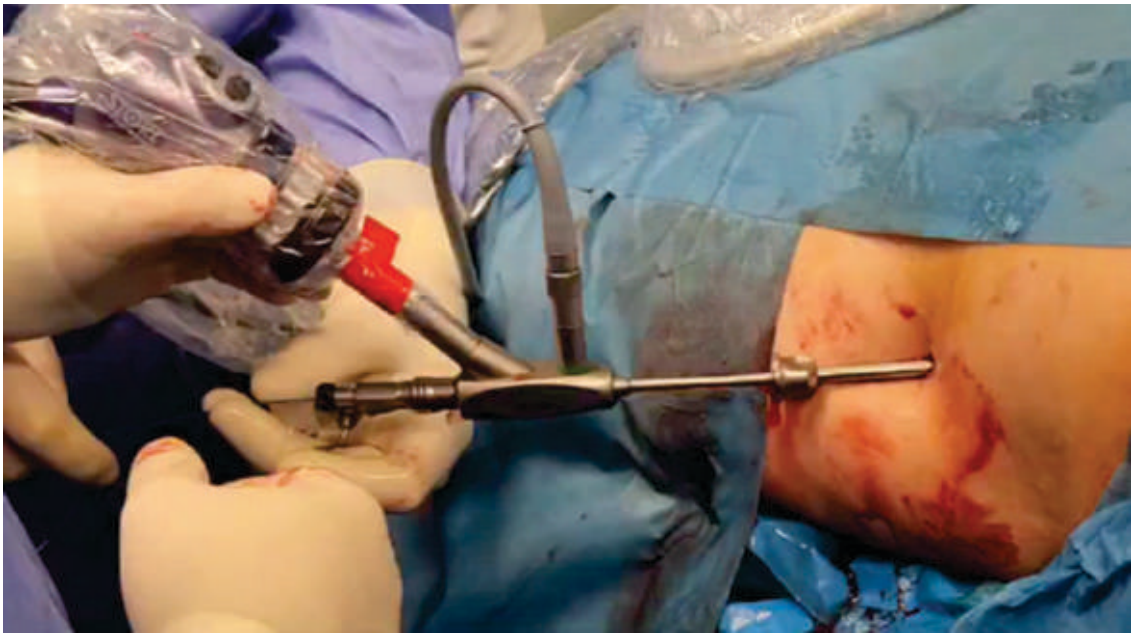


Figure 3. The 12 Fr nephroscope and 15/16 Fr access sheaths MIP-M

A nephrostomy tube was placed at the end of all procedures. Ten cases needed double J ureteral stenting at the end of procedure instead of ureteral catheter.

Data collection

The primary end-point of the study, stone-free rate (SFR), was assessed by abdominopelvic native computed tomography at 3-4 weeks after surgery.
We recorded the following preoperative data: gender, age, body mass index (BMI), laterality of the procedure, specific sectional imaging features (calculi dimensions, number of calculi, retrorenal colon etc.), preoperative serum creatinine. The intraoperative and postoperative characteristics were recorded: total operative time, number of tracts, number of patients who required blood transfusion (and number of transfusions), perioperative complications, postoperative haemoglobin, postoperative hospital stay, the presence of catheters (ureteral stent / nephrostomy tube).

Statistical analysis

We used Microsoft Excel to evaluate the characteristics of the study group. For quantitative variables, data normality was verified by using the Shapiro-Wilk test. All the patients gave their informed consent for participation in this study.

RESULTS

During the specified period, a total of 100 patients, 63 males and 37 females, underwent mini-PCNL in supine position in our department. The median age of the patients was 53 years (range 27–73). Fifteen patients were above the age of 65. The median BMI was 25.5 kg/m2 (range: 20.0-32.5). Ten patients required two percutaneous tracts in order to achieve the maximal stone clearance. The median stone size was 26 mm (range: 15-50 mm). The median hardness of the stones was 1100 HU (range: 600-1500). The initial preoperative urine culture was positive in 25 patients. In 59 cases we performed the procedure on the left side, while in 41 cases on the right side. We didn't perform no any bilateral procedure during the same admission.

The median operative time was 60 minutes (range 30-150 minutes). Mean postoperative hospital stay was 2.4 days. The stone free rate was 82% evaluated by abdominopelvic computed tomography. The renal pelvis injury was encountered in two cases, successfully managed by ureteral JJ stenting. Postoperative hemorrhage didn't require blood

transfusion or any other intervention (e.g. angioembolization), being managed only with bed rest, parenteral hemostatic, antibiotics, analgesic and intravenous fluid therapy. Two other cases had CLAVIEN II complication (fever and sepsis, respectively). The nephrostomy tube was removed in postoperative day one in 90 cases, while the other ten cases required the nephrostomy tube to be maintained for one or two more days. The indication for ureteral JJ stent placement was migration of stone fragment on the ureter in four cases, free stone fragments inaccessible with the nephroscope in four cases and renal pelvis injury in two cases, respectively. The mean drop in hemoglobin was 1.2 ± 0.8 g/dL. Four patients with staghorn calculi required additional percutaneous procedure in other admission, while for the others with incomplete stone clearance we perform retrograde ureteroscopy or surveillance, if the patient refused another surgical procedure.

DISCUSSIONS

Since the first extraction of stones using the percutaneous approach by Fernstrom and Johansson in 1976 [14], the technology and technique evolved, as well as knowledge about surgical approaches. Supine PCNL was first described by Valdivia et al. in 1987 and later gained popularity in 1998 through the efforts of the same authors. The miniaturized PCNL (mini-PCNL) technique, introduced by Jackman et al. in 1998 in pediatric patients, developed as a need to reduce the access sheath caliber with the aim of decreasing the risk of hemorrhage and urinary leak [15,16]. The present study was designed to focus on our initial experience in supine mini-PCNL, comparing our technique and outcomes with existing studies.

Since the introduction of mini-PCNL, multiple studies were published in literature about the efficacy and safety profile of technique, including numerous prospective randomized controlled trials (RCTs) and nonrandomized studies, comparing its efficacy to that of standard PCNL [17].

A systematic review and meta-analysis published in 2022 comparing the safety and efficacy of mini-PCNL with those of standard approach in the treatment of renal stone disease, included 16 RCTs with 3961 patients. The SFR was comparable between the two groups (risk ratio [RR]=1.01 [0.99, 1.04], p = 0.30), as well as the need for auxiliary procedures (RR=0.77 [0.58, 1.03], p = 0.08), but the operative time was significantly more prolonged in the first group (MD 8.28 [3.96,12.59], p = 0.000). The hemoglobin decreasing (mean difference [MD] −0.67 [−0.93, −0.41], p = 0.000), perioperative complications (RR 0.89 [0.79, 0.97], p = 0.01) and length of stay (MD −0.59 [−0.81, −0.37], p = 0.000) were lower with mini-PCNL [17].

In a matched pair analysis by Ozdemir et al., the outcomes of supine and prone mini-PCNL were compared in patients with lower pole, middle pole, and renal pelvic stones. The study included 54 patients who underwent supine mini-PCNL and 108 matched patients who underwent the procedure in prone position. The results indicated that the first group had significantly shorter operation times compared to the prone group (58.1±45.9 versus 80.1±40.0 minutes, p=0.025). Additionally, fluoroscopy time was notably reduced in the supine position versus the prone position (3.0±1.7 versus 4.9±4.5 minutes, p=0.01). Both groups demonstrated comparable success rates, with 72.2% in the supine mini-PCNL group and 71.3% in the other group (p=0.902). The overall complication rates were similar between the two positions. These findings suggest that supine mini-PCNL offers advantages in terms of reduced operation and fluoroscopy times while maintaining efficacy and safety comparable to the prone approach. The supine position may also provide benefits such as easier patient positioning and improved access for anesthesiologists during the procedure [18].

The application of miniaturized percutaneous approaches in patients with a larger and complex stones has been questioned. The initial studies considered mini-PCNL as an extension of indications for standard PCNL, only for renal calculi of 1-2 cm, given the smaller sheath diameter that increase the operating time. In the study published by Abdelhafez et al., the effectiveness and safety of minimally invasive percutaneous nephrolitholapaxy (MIP) were evaluated in 73 patients with 83 renal units with large renal stones

(>20 mm in diameter). The stones were categorized as either simple (isolated renal pelvis or calyceal stones) or complex (partial or complete staghorn stones, or renal pelvis with calyceal stones). The mean stone diameter was 36.7±23.37 mm, and the mean operative time was 99.2 ± 48.3 minutes. After the initial procedure, 78.3% of cases were stone-free. Notably, the only significant difference between complex and simple stones was the stone-free rate (96.9% vs. 66.7%, P=0.001). Complications occurred in 26.5% of procedures, predominantly classified as Clavien Grade 1 or 2, with no Grade 4 or 5 complications reported. The study concluded that the MIP technique is effective and safe for larger stones, offering a high success rate with low morbidity and reasonable operative times. [19,20].
Different lithotripsy modalities can be used, with variable efficiency of stone fragmentation. LASER lithotripsy has become the preferred technique among surgeons due to its high effectiveness. Compared to pneumatic and ultrasonic lithotripsy, it is associated with decreased operative time, particularly in patients with a large stone burden [21].

Two key factors contribute to the longer duration of mini-PCNL procedures. First, the limited visualization provided by the mini-nephroscope makes the surgery more challenging. Second, to allow stone fragments to pass through the smaller tract, the stones must be broken into smaller pieces, which significantly extends the procedure time. However, recent studies indicate that the supine position is associated with shorter operative times in both standard and mini-PCNL compared to other patient positions. In mini-PCNL we rarely used additional instruments to extract the stone fragments. The vortex effect, enhanced by gravitational forces and greater mobility within the pelvicalyceal system that comes with supine position, can partially explain the reduced operative time when compared with the prone approach [21].

Our results regarding stone-free rate, operative time, length of stay were comparable with those published in the mentioned studies, with better results as we gained experience with this type of approach.

The reduction of blood loss, hemorrhagic complications, blood transfusion, postoperative pain is explained by the reduction in renal trauma. The size of the access sheath is reduced from 24-30 French to 12-20 French. It was shown that decreasing the access sheath size from 24F to 18F results in a surface area reduction by up to 78% [22]. We didn't experience Clavien III-IV perioperative hemorrhagic complications.

One of the most significant advantages of supine mini-PCNL is its suitability for patients with comorbidities, particularly those with cardiopulmonary conditions. The supine position facilitates better respiratory dynamics and hemodynamic stability, reducing the risk of intraoperative complications compared to the prone position. For patients with obesity, advanced age, or limited mobility, the supine approach minimizes the risks associated with prolonged prone positioning, including pressure-related injuries and difficulties with airway management. Additionally, supine positioning allows for more efficient intraoperative monitoring and anesthesia management, making it a safer option for high-risk surgical candidates [11,12].

Supine mini-PCNL is also advantageous in patients with anatomical abnormalities that complicate access to the renal collecting system. For instance, patients with spinal deformities, such as kyphosis or scoliosis, may not tolerate prone positioning well, making supine PCNL a more feasible alternative [11,12].

The efficiency of the supine mini-PCNL can be increased by using simultaneous retrograde intrarenal surgery (ECIRS) for complex stone cases that require combined endourological approaches. It adapts the procedure to the patient, stones, and anatomy of the collecting system [23].

Overall, the evidence supports the use of supine mini-PCNL as a first-line treatment for large and/or complex renal lithiasis, particularly in patients with comorbidities or anatomical challenges. The procedure offers comparable efficacy with significant advantages in patient safety, anesthesia management, and operative efficiency. While further

research, including randomized controlled trials, may help solidify its role as the preferred approach, current data suggest that supine mini-PCNL should be considered a feasible and safe option in modern endourological practice [17,21].

CONCLUSIONS

The findings of this study demonstrated that supine mini-PCNL is an effective and safe technique for the management of renal lithiasis in our department, achieving high stone-free rates with a favorable safety profile, contributing to the existing evidence about this type of approach.

REFERENCES

[1] Sorokin I, Mamoulakis C, Miyazawa K, Rodgers A, Talati J, Lotan Y. Epidemiology of stone disease across the world. World J Urol. 2017;35(9):1301–1320. doi: 10.1007/s00345-017-2008-6.

[2] Ferraro P.M., Curhan G.C., D'Addessi A., Gambaro G. Risk of recurrence of idiopathic calcium kidney stones: Analysis of data from the literature. J. Nephrol. 2017;30:227–233. doi: 10.1007/s40620-016-0283-8.

[3] Zeng G, Zhong W, Pearle M, Choong S, Chew B, Skolarikos A, Liatsikos E, Pal SK, Lahme S, Durutovic O, Farahat Y, Khadgi S, Desai M, Chi T, Smith D, Hoznek A, Papatsoris A, Desai J, Mazzon G, Somani B, Eisner B, Scoffone CM, Nguyen D, Ferretti S, Giusti G, Saltirov I, Maroccolo MV, Gökce MI, Straub M, Bernardo N, Lantin PL, Saulat S, Gamal W, Denstedt J, Ye Z, Sarica K. European Association of Urology Section of Urolithiasis and International Alliance of Urolithiasis Joint Consensus on Percutaneous Nephrolithotomy. Eur Urol Focus. 2022 Mar;8(2):588-597. doi: 10.1016/j.euf.2021.03.008.

[4] Seitz C, Desai M, Häcker A, Hakenberg OW, Liatsikos E, Nagele U, Tolley D. Incidence, prevention, and management of complications following percutaneous nephrolitholapaxy. Eur Urol. 2012 Jan;61(1):146-58. doi: 10.1016/j.eururo.2011.09.016.

[5] Jackman SV, Docimo SG, Cadeddu JA, Bishoff JT, Kavoussi LR, Jarrett TW. The "mini-perc" technique: a less invasive alternative to percutaneous nephrolithotomy. World J Urol 1998;16:371–4.

[6] Helal M, Black T, Lockhart J, Figueroa TE. The Hickman peel-away sheath: alternative for pediatric percutaneous nephrolithotomy. J Endourol 1997;11:171–2.

[7] Chung DY, Kang DH, Cho KS, et al. Comparison of stone-free rates following shock wave lithotripsy, percutaneous nephrolithotomy, and retrograde intrarenal surgery for treatment of renal stones: A systematic review and network meta-analysis PLoS One 2019 Feb 21;14(2):e0211316. doi: 10.1371/journal.pone.0211316. eCollection 2019.

[8] Wymer KM, Sharma V, Juvet T, et al. Cost-effectiveness of Retrograde Intrarenal Surgery, Standard and Mini Percutaneous Nephrolithotomy, and Shock Wave Lithotripsy for the Management of 1-2cm Renal Stones-Urology 2021 Oct;156:71-77. doi: 10.1016/j.urology.2021.06.030. Epub 2021 Jul 15.

[9] Nagele U, Schilling D, Anastasiadis AG, et al. A Stenzl-Minimally invasive percutaneous nephrolitholapaxy (MIP)]- Urologe A 2008 Sep;47(9):1066, 1068-73. doi: 10.1007/s00120-008-1814-2.

[10] Valdivia Uría JG, Lachares Santamaría E, Villarroya Rodríguez S, Taberner Llop J, Abril Baquero G, Aranda Lassa JM. Nefrolitectomía percutánea: técnica simplificada (nota previa) [Percutaneous nephrolithectomy: simplified technic (preliminary report)]. Arch Esp Urol. 1987 Apr;40(3):177-80. Spanish.

[11] Kumar P, Bach C, Kachrilas S, Papatsoris AG, Buchholz N, Masood J. Supine percutaneous nephrolithotomy (PCNL): 'in vogue' but in which position? BJU Int. 2012;110(11 Pt C):E1018–E1021. doi: 10.1111/j.1464-410X.2012.11188.x.

[12] Proietti S, Rodríguez-Socarrás ME, Eisner B, De Coninck V, Sofer M, Saitta G, Rodriguez-Monsalve M, D'Orta C, Bellinzoni P, Gaboardi F, Giusti G. Supine percutaneous nephrolithotomy: tips and tricks. Transl Androl Urol. 2019 Sep;8(Suppl 4):S381-S388. doi: 10.21037/tau.2019.07.09.

[13] Tikkinen RC, Gould MK, Naspro R, et al. Thromboprophylaxis; EAU Guidelines Edn presented at the EAU Annual Congress Amsterdam; 2020. ISBN 978-94-92671-07-3.

[14] Fernström I, Johansson B. Percutaneous pyelolithotomy. A new extraction technique. Scand J Urol Nephrol. 1976;10(3):257-9. doi: 10.1080/21681805.1976.11882084.

[15] Jackman SV, Hedican SP, Peters CA, Docimo SG. Percutaneous nephrolithotomy in infants and preschool age children: experience with a new technique. Urology. 1998 Oct;52(4):697-701. doi: 10.1016/s0090-4295(98)00315-x.
[16] Jackman SV, Docimo SG, Cadeddu JA, Bishoff JT, Kavoussi LR, Jarrett TW. The "mini-perc" technique: a less invasive alternative to percutaneous nephrolithotomy. World J Urol. 1998;16:371-4.
[17] Sharma G, Sharma A, Devana SK, Singh SK. Mini Versus Standard Percutaneous Nephrolithotomy for the Management of Renal Stone Disease: Systematic Review and Meta-analysis of Randomized Controlled Trials. Eur Urol Focus. 2022 Sep;8(5):1376-1385. doi: 10.1016/j.euf.2021.07.014.
[18] Ozdemir H, Erbin A, Sahan M, Savun M, Cubuk A, Yazici O, Akbulut MF, Sarilar O. Comparison of supine and prone miniaturized percutaneous nephrolithotomy in the treatment of lower pole, middle pole and renal pelvic stones: A matched pair analysis. Int Braz J Urol. 2019 Sep-Oct;45(5):956-964. doi: 10.1590/S1677-5538.IBJU.2019.0049.
[19] Lahme S, Bichler KH, Strohmaier WL, Götz T. Minimally invasive PCNL in patients with renal pelvic and calyceal stones. Eur Urol. 2001 Dec;40(6):619-24. doi: 10.1159/000049847. PMID: 11805407.
[20] Abdelhafez MF, Bedke J, Amend B, ElGanainy E, Aboulella H, Elakkad M, Nagele U, Stenzl A, Schilling D. Minimally invasive percutaneous nephrolitholapaxy (PCNL) as an effective and safe procedure for large renal stones. BJU Int. 2012 Dec;110(11 Pt C):E1022-6. doi: 10.1111/j.1464-410X.2012.11191.x.
[21] Qin P, Zhang D, Huang T, Fang L, Cheng Y. Comparison of mini percutaneous nephrolithotomy and standard percutaneous nephrolithotomy for renal stones >2cm: a systematic review and meta-analysis. Int Braz J Urol. 2022 Jul-Aug;48(4):637-648. doi: 10.1590/S1677-5538.IBJU.2021.0347. PMID: 34786926; PMCID: PMC9306366.
[22] Zeng G, Cai C, Duan X, Xu X, Mao H, Li X, Nie Y, Xie J, Li J, Lu J, Zou X, Mo J, Li C, Li J, Wang W, Yu Y, Fei X, Gu X, Chen J, Kong X, Pang J, Zhu W, Zhao Z, Wu W, Sun H, Liu Y, la Rosette J. Mini Percutaneous Nephrolithotomy Is a Noninferior Modality to Standard Percutaneous Nephrolithotomy for the Management of 20-40mm Renal Calculi: A Multicenter Randomized Controlled Trial. Eur Urol. 2021 Jan;79(1):114-121. doi: 10.1016/j.eururo.2020.09.026.
[23] Cracco CM, Scoffone CM. Endoscopic combined intrarenal surgery (ECIRS) - Tips and tricks to improve outcomes: A systematic review. Turk J Urol. 2020 Nov;46(Supp. 1):S46-S57. doi: 10.5152/tud.2020.20282.