

Outpatient Percutaneous Nephrolithotomy, An Interesting Option: A Systematic Review

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Purpose: The prevalence of kidney stone disease is rising, with modern surgical approaches emphasizing minimally invasive techniques like ambulatory percutaneous nephrolithotomy (PCNL). This strategy offers potential benefits such as reduced costs and improved efficiency. However, its safety and feasibility require further evaluation.

Materials and Methods: A systematic review was conducted following PRISMA guidelines. Databases including PubMed, Embase, Scopus, and the Cochrane Library were searched for studies on ambulatory PCNL published between 1986 and 2024. Of 2,381 identified studies, 17 met the inclusion criteria. Data were analyzed regarding patient selection, technical modifications, surgical outcomes, and complications.

Results: The review included 456 patients undergoing 459 procedures. Ambulatory PCNL was feasible for highly selected patients meeting strict criteria (ASA <3, BMI <35 kg/m², no major comorbidities, and minimal stone burden). The mean operative time was 103 minutes, with an average hospital stay of 6.4 hours. The procedure achieved a 93% stone clearance rate, with 15% experiencing mild complications (Clavien-Dindo grade 1-2) and 4.6% requiring readmission. Severe complications (grade 3-4) were rare (0.4%).

Conclusion: Ambulatory PCNL is a safe, efficient option for select patients, optimizing healthcare resources and improving patient outcomes. Wider adoption requires standardized protocols and multicenter studies to expand its application.

Keywords: outpatient; percutaneous nephrolithotomy; stone surgery; day surgery

INTRODUCTION

Historically, open surgery was performed to remove kidney stones, a procedure associated with high morbidity and a long recovery time. Percutaneous nephrolithotomy (PCNL) was first described by Fernstrom and Johansson in 1976 and later popularized by White and Smith as an effective and safe surgical modality.^(1,2) Many modifications to the original procedure have been developed to decrease morbidity and improve outcomes. Today, PCNL is considered the gold standard for the management of high-burden kidney stone disease, demonstrating an earlier stone-free status and a lesser need for re-intervention compared to extracorporeal shock wave lithotripsy (ESWL) for stones larger than 2 cm.⁽³⁾

Compared with open procedures, PCNL has been associated with less morbidity, a lower transfusion rate, a shorter convalescence, and lower cost.⁽⁴⁾ Unlike most endourologic procedures, many urology teams still perform PCNL on an inpatient basis for a period of 2-4 days. This allows for surveillance of postoperative bleeding and infection, management of the nephrostomy tube, and assessment of the need for an auxiliary procedure. An overall complication rate of 7% to 10.5% (Clavien-Dindo grade 3 to 5) has been reported by several urology teams, with this rate being even lower for

low-burden stone disease (e.g., solitary, pelvic stones).⁽⁵⁾

Ambulatory PCNL was first described by Preminger in 1986 and offers potential advantages such as shorter convalescence, a lower risk of nosocomial infections, and alleviation of the healthcare system burden (both financially and in terms of hospital bed vacancies).⁽⁶⁾ Crucial technical modifications were required to popularize this technique. The original technique involved placing a large-bore nephrostomy tube postoperatively to tamponade the tract, impede hemorrhage, allow urine drainage, permit second-look interventions for residual fragments, and prevent urinoma formation.⁽⁷⁾ Several modifications have been described to replace the postoperative nephrostomy tube with an indwelling ureteral stent or to perform a completely tubeless technique to decrease postoperative discomfort and analgesic requirements.

PCNL has many potential complications, such as bleeding, infection, injury to adjacent organs, and postoperative renal impairment. Indeed, kidney tubular injury is a potential complication influenced by patient comorbidities and perioperative factors.⁽⁸⁾ Colon perforation is a rare but significant complication, with no consensus on optimal management due to limited reported cases and diverse treatment approaches.⁽⁹⁾

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Table 1. Patients' demographics, stone characteristics, and intraoperative variables

Article	Study Type	N (Patients) Procedures	Mean Age (yrs)	Male/Female Ratio	Mean BMI (kg/m ²)	ASA Class I/II/III	Stone History (%)	Stone Size (mm)	Multiple Stones (%)	Percutaneous Access	Lithotripsy
Preminger et al. ⁽⁶⁾	Retrospective	5	30	0.2	N/A	N/A	N/A	10	0	Middle calix (100%)	None (intact extraction)
Singh et al. ⁽⁷⁾	Retrospective	10	48.1	N/A	N/A	N/A	N/A	20	N/A	Upper (20%), Middle (70%)	Ballistic
Shahrouf et al. ⁽²⁴⁾	Prospective	10	53	1.5	25.9	2/8/N/A	N/A	22.4	2	Middle calix (70%)	Ballistic
El Tabey et al. ⁽¹⁶⁾	Retrospective	60	38.5	1.53	25	N/A	N/A	N/A	N/A	Lower calix (77.4%)	Ballistic
Sharma et al. ⁽³³⁾	Prospective	34	38.6	N/A	N/A	N/A	N/A	N/A	N/A	Upper (38%), Lower (56%)	Ballistic
Beiko et al. ⁽²⁵⁾	Retrospective	52	55.8	1.08	29.3	9/33/8	35	19.6	22	Mixed	Mixed (Ultrasonic + Ballistic)
Kumar et al. ⁽²⁶⁾	RCT	56	36.2	1.2	N/A	N/A	N/A	30.2	14	Middle calix (44%)	Ballistic
Fahmy et al. ⁽³²⁾	Retrospective	146	43	1.7	31	N/A	100	N/A	N/A	N/A	N/A
Bechis et al. ⁽³⁰⁾	Retrospective	60	54.9	1.5	27.8	3/31/25	60	18.4	N/A	Upper (28%), Middle (44%)	Mixed (Ballistic + Laser)
Tian et al. ⁽³⁵⁾	Prospective	18	42.9	N/A	N/A	N/A	N/A	19.2	N/A	N/A	Laser
Schoenfeld et al. ⁽³⁶⁾	Prospective	47	53.0	N/A	30.4	N/A	N/A	23.4	N/A	N/A	N/A
Zhu et al. ⁽³⁷⁾	Prospective	175	51.7	N/A	23.6	N/A	N/A	27	91	N/A	N/A
Roberts et al. ⁽³⁸⁾	Retrospective	134	56.2	N/A	27	79/55/N/A	N/A	18.5	N/A	N/A	N/A
Thakker et al. ⁽³⁹⁾	Retrospective	53	59	N/A	32	N/A	N/A	N/A	N/A	N/A	Dual ultrasound
Siron et al. ⁽⁴⁰⁾	Retrospective	38	52.2	N/A	26.5	33/5/N/A	N/A	25.3	N/A	N/A	N/A
Shakiba et al. ⁽⁴¹⁾	Prospective	32	46.06	N/A	27.25	N/A	N/A	33.3	N/A	N/A	N/A

Recently, several teams have described ambulatory tubeless PCNL for selected patients meeting strict criteria. Therefore, the aim of the present review is to describe the technical modifications for ambulatory PCNL, assess its safety and feasibility, and identify the

ideal patient population for this strategy.

MATERIALS AND METHODS

Search Strategies and Studies Selection

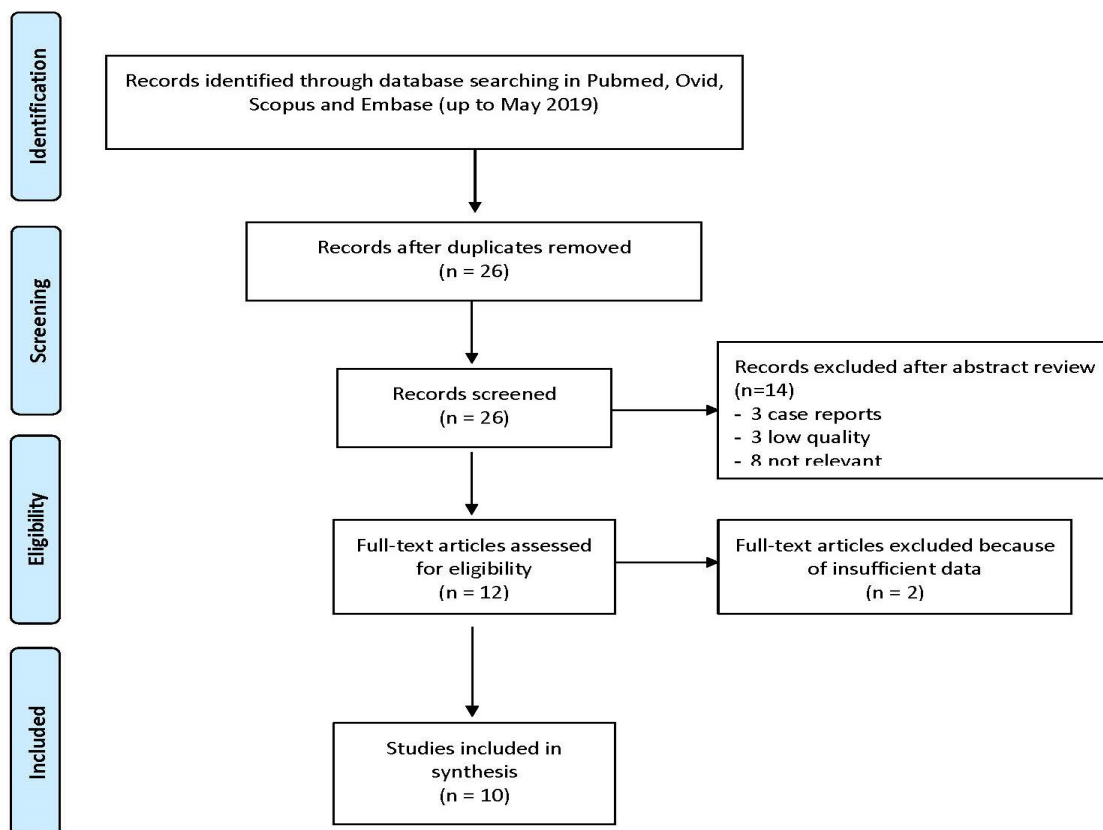


Figure 1. PRISMA Flow Chart

Table 2. Outpatient PCNL outcome

Article	Mean Operative Time (min)	Mean Hospital Stay (min)	Mean Narcotic Requirements (mg oral morphine)	ED Consultation within 7 days (%)	Readmission Rate (%)	Stone-Free Rate (%)	Complications Rate Grade 1-2	Complications Rate Grade 3-4
Preminger et al. ⁽⁶⁾	124	180	N/A	0	0	100	0	0
Singh et al. ⁽⁷⁾	48.4	2400	N/A	0	0	100	0	0
Shahrour et al. ⁽²⁴⁾	83.5	240	19.25	10	10	N/A	10	10
El Tabey et al. ⁽¹⁶⁾	46.6	N/A	N/A	N/A	N/A	91.7	18.3	0
Sharma et al. ⁽³³⁾	72	750	N/A	8.8	5	100	8.8	0
Beiko et al. ⁽²⁵⁾	N/A	208.32	41.13	6	4	90.4	18	0
Kumar et al. ⁽²⁶⁾	41.3	691.2	N/A	N/A	7.1	96.4	19.6	0
Davalos et al. ⁽³⁴⁾	148	285	N/A	12	4	92	8	4
Fahmy et al. ⁽³²⁾	84	540	N/A	3	1.3	88.9	12.3	0
Bechis et al. ⁽³⁰⁾	N/A	N/A	N/A	18	10	97	20	N/A
Zhu et al. ⁽³⁷⁾	74.6	1440	N/A	0	1.5	88.8	23.3	10
Thakker et al. ⁽³⁹⁾	86	N/A	"low dose oral narcotics"	4	2	N/A	N/A	N/A

A systematic review of the literature was performed up to October 2024, in accordance with The Cochrane Guidelines and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Figure 1). Bibliographic databases searched included Medline, Embase, Ovid, Cochrane, Web of Science, and Scopus. No language restrictions were applied. The search terms used were as follows: “percutaneous nephrolithotomy”, or “nephrolithotomy”, or “PCNL”, and “outpatient”, or “same day”, or “ambulatory surgery”. The reference lists of included articles were reviewed to identify additional studies.

Out of 2,381 studies identified in the initial pool, 17 met the inclusion criteria. After excluding duplicate records and reviewing titles and abstracts, a total of 43 potential publications were identified. Twenty-four articles were excluded after screening abstracts (3 case reports, 3 due to low quality, and 18 not relevant). Nineteen full-text articles were assessed for eligibility, with two of them excluded due to insufficient data. Seventeen studies were finally included in the review.

Inclusion and Exclusion Criteria

The Population (P) consisted of adults undergoing PCNL, the Intervention (I) focused on outpatient PCNL procedures, the Comparison (C) involved inpatient PCNL or discharge protocols exceeding 24 hours, and the Outcome (O) evaluated safety, feasibility, complication rates, readmission rates, stone clearance, patient satisfaction, and healthcare cost-efficiency. Two of the authors (AB and EA) performed the article selection. We included all studies evaluating outpatient PCNL surgical outcomes and feasibility, published since 1986. We excluded studies not solely focused on PCNL, pediatric PCNL, review articles, comments, editorials, case reports, and in-vitro or animal experiments.

Data Extraction and Assessment of Methodologic Quality

Titles and abstracts were independently assessed for inclusion by two reviewers (A.B. and E.A.). All potentially relevant articles were obtained, and their suitability was reassessed after reading the full text. Data were then independently extracted by two reviewers (A.B. and F.B.) and presented in structured tables. The methodological quality of each included study was assessed by two reviewers. The risk of bias was evaluated according to the description of the following parameters: random sequence generation, selective reporting, coefficient of variation, incomplete outcome data, blinding, and other bias. Bias was classified as low, high, or unclear risk (Figure 2). Disagreements were resolved through discussion or consultation with a third independent reviewer.

RESULTS

A total of 17 studies were included in the final analysis, of which 10 were retrospective and 7 were prospective. No comparative studies between ambulatory and conventional PCNL were identified. Ambulatory PCNL was performed on 456 patients across 459 procedures (3 patients were operated on bilaterally).

All patients were highly selected according to strict preoperative, intraoperative, and postoperative criteria. Candidates for ambulatory PCNL were typically young adults with no significant comorbidities (ASA <3, BMI < 35 kg/m², no cardiac disease, no renal insufficiency, no congenital kidney abnormalities, transplant, or solitary kidney) and minimal stone burden with no active urinary tract infection. It was also required that patients have adequate family support and reside close to the

Table 3. Preoperative selection criteria

Article	Age >18	ASA Score <3	BMI <35 kg/m ²	No Solitary/ Transplanted Kidney	No Active Cardiac Disease	No Renal Insufficiency	No Active UTI	No Encrusted Stone	Minimal Stone	Family Support	Short Distance
Shahrour et al.(24)	N/A	Yes	Yes	Yes	Yes	N/A	N/A	N/A	Yes	Yes	Yes
El Tabey et al.(16)	Yes	Yes	Yes	Yes	N/A	N/A	Yes	N/A	Yes	N/A	Yes
Beiko et al.(25)	N/A	Yes	Yes	Yes	Yes	N/A	Yes	N/A	Yes	Yes	Yes
Kumar et al.(26)	Yes	Yes	Yes	N/A	N/A	Yes	Yes	N/A	Yes	Yes	Yes
Davalos et al.(34)	N/A	Yes	N/A	Yes	N/A	N/A	Yes	N/A	Yes	N/A	Yes
Fahmy et al.(32)	N/A	Yes	N/A	Yes	N/A	Yes	N/A	N/A	Yes	Yes	Yes
Bechis et al.(30)	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	Yes
Zhu et al.(37)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Thakker et al.(39)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No cutoff	Yes	Yes	Yes

Table 4. Intraoperative and postoperative selection criteria

Article <3 Punctures	No Multiple Tracts	No Residual Stones	No Perforation/ Bleeding	Hemodynamically Stable	Adequate Pain Control	Normal Chest Radiography	Ability to Ambulate	Successful Trial to Void*	
Chong et al. ⁽³¹⁾	Yes	N/A	Yes	N/A	Yes	Yes	N/A	N/A	Yes
Singh et al. ⁽⁷⁾	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A	N/A
Shahrour et al. ⁽²⁴⁾	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes
El Tabey et al. ⁽¹⁶⁾	Yes	N/A	Yes	Yes	Yes	Yes	N/A	Yes	Yes
Beiko et al. ⁽²⁵⁾	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kumar et al. ⁽²⁶⁾	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A	N/A
Davalos et al. ⁽³⁴⁾	N/A	N/A	N/A	Yes	Yes	Yes	N/A	N/A	N/A
Bechis et al. ⁽³⁰⁾	N/A	N/A	N/A	N/A	Yes	Yes	N/A	N/A	Yes
Zhu et al. ⁽³⁷⁾	Yes	Yes	Yes	Yes	Yes	Yes	N/A	Yes	Yes
Thakker et al. ⁽³⁹⁾	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

* unless discharged with indwelling catheter

hospital. The intervention was required to have less than three punctures for access and no multiple tracts. Patients could not have residual stones necessitating a second-look nephroscopy or have experienced pelvicalyceal perforation or excessive bleeding. Postoperatively, patients needed to be hemodynamically stable with a hematocrit >30%, have adequate pain control, be able to ambulate early, and void adequately.

Regarding stone fragmentation, ballistic lithotripsy was the most frequently used method. For renal drainage, only 4 patients were totally tubeless. An antegrade ureteral stent was inserted in most patients (49.5%), followed by a retrograde ureteral stent (40.8%).

The mean operative time was 103 minutes (range, 41.3-203). All patients were discharged on the same day, with a mean postoperative hospital stay of 384 minutes (range, 208-750), except for 10 patients who were discharged on day 1 with a mean hospital time of 11.03 hours. The stone-free rate was estimated at approximately 93% (defined as the absence of stone fragments or fragments ≤ 2 mm).

Twenty-nine patients (6.3%) presented to the emergency department within 7 days postoperatively, of whom 21 (4.6%) were readmitted. Fifteen percent of patients developed early postoperative complications, of whom 0.4% were classified as Clavien-Dindo grade 3 or 4.

DISCUSSION

The prevalence of kidney stone disease and the inci-

dence of stone-related events have shown a constant rise. Modern kidney stone surgery increasingly utilizes ambulatory surgical centers, which have demonstrated optimal quality of care, substantial patient satisfaction, low cost to the healthcare system, and improved surgeon efficiency. In fact, ambulatory PCNL, which is most often performed tubeless, has been shown to be a safe procedure in selected patients, with a high stone clearance rate, few complications, and a low readmission rate.^(10,11)

Patient Selection

Strict selection criteria should be applied when considering an outpatient PCNL. The most common criteria include: preoperative (American Society of Anesthesiologists (ASA) score < 3, body mass index (BMI) < 35 kg/m², no solitary/transplanted kidney, no active cardiac disease, no renal insufficiency, no active urinary tract infection, no encrusted stents, minimal stone burden, family support, short distance between hospital and home), intraoperative (< 3 punctures to obtain access, no multiple tracts, no residual stones necessitating second-look nephroscopy, no pelvicalyceal perforation or excessive bleeding), and postoperative (hemodynamically stable, hematocrit > 30, adequate pain control).

Technical Modifications

Conventional PCNL involves the introduction of a nephrostomy tube to decrease postoperative complications or maintain a tract for a second look. In high-vol-

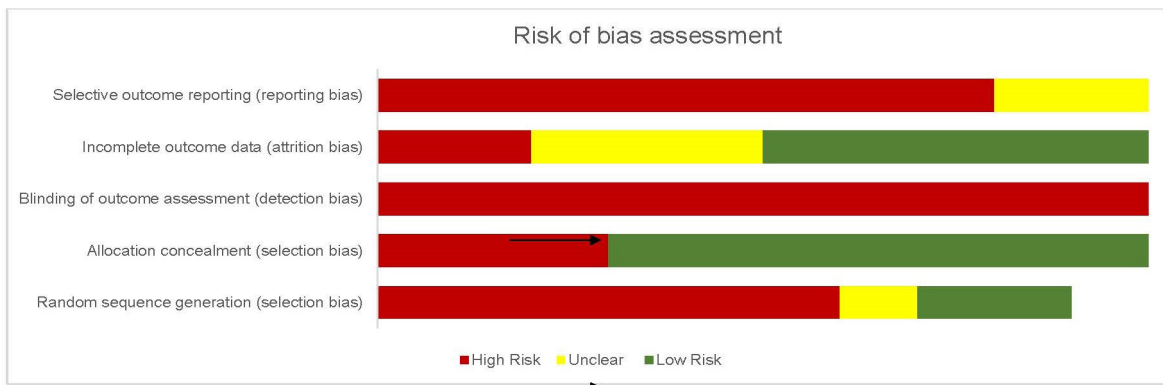


Figure 2. Risk of bias assessment

ume centers, several endourology teams have reported a tubeless technique with or without hemostatic agents. The use of hemostatic agents has shown significant hemostasis control, reduced analgesic requirements, and faster convalescence. Various hemostatic agents have been used, such as a composite agent (Surgicel, tranexamic acid, noradrenaline, and Trasograf), gelatin packing, and systemic tranexamic acid, which has been associated with reduced blood loss and postoperative complications.⁽¹²⁻¹⁴⁾ This major modification has encouraged more teams to perform ambulatory PCNL. However, a 2014 meta-analysis did not demonstrate any significant benefit of PCNL-tract sealants.⁽¹⁵⁾

Anesthetic Modification

Although most urology teams perform PCNL under general anesthesia, the first ambulatory PCNL procedures described by Preminger were under local anesthesia with sedation. In other studies, high subarachnoid spinal anesthesia was reported.⁽¹²⁻¹⁶⁾ Singh et al. reported the technique of tubeless PCNL performed under regional anesthesia in selected cases, with all ten patients discharged uneventfully the next day.⁽¹⁷⁾ Postoperative multilevel intercostal anesthetic nerve blocks have also been used.⁽¹⁸⁾ These techniques have been effective in decreasing postoperative pain, analgesic requirements, and nausea, thereby accelerating postoperative ambulation.⁽¹⁹⁾

Smaller-Bore Percutaneous Tract

Mini-PCNL (15-20 Fr) is a good alternative to conventional PCNL (30 Fr), featuring a smaller diameter tract. A 2015 meta-analysis showed a decrease in postoperative blood transfusion, shorter hospital stays, and less postoperative pain.⁽²⁰⁾ These factors could popularize this technique for ambulatory PCNL, especially for low-burden renal lithiasis.

Lithotripters

Four energy sources are available for intracorporeal lithotripsy: pneumatic, ultrasound, laser, and electrohydraulic.⁽²¹⁾ The rapid development of high-power lithotripters (e.g., Stonebreaker, high-power Holmium:YAG laser) could increase the stone-free rate and decrease operative time, which would help in discharging patients earlier.⁽²²⁾

Feasibility

Several procedural refinements have facilitated outpatient PCNL, such as the urologist mastering renal access instead of relying on an interventional radiologist. This strategy has shown optimal stone treatment with a high stone clearance rate without additional patient discomfort.⁽²³⁾ In our analysis, only 0.4% of patients had serious postoperative complications (Clavien-Dindo grade 3-4).

In 2010, Shahrour et al. demonstrated the feasibility of the outpatient PCNL approach in an initial series of 10 patients.⁽²⁴⁾ In 2013, Tabey et al. showed that ambulatory PCNL was successfully accomplished in 60 out of 84 patients (71.4%), with a 91.7% stone-free rate and only 6% experiencing grade 1 Clavien-Dindo complications.⁽¹⁶⁾ Beiko et al. documented a series of 52 patients who underwent ambulatory PCNL, all discharged on the same day with a mean hospital stay of 208 minutes. Only 4% of patients were readmitted, and the overall stone-free rate was 90.4%.⁽²⁵⁾ Santosh et al., in a randomized controlled trial, showed that tubeless

day-care PCNL with a composite hemostatic tract seal is safe and resulted in a significant reduction in blood loss, analgesic requirements, and hospital stay.⁽²⁶⁾ Furthermore, Kokorovic et al. were the first to describe a successfully completed outpatient bilateral supracostal tubeless PCNL for staghorn calculi.⁽²⁷⁾

Surgical advancements have enabled the use of tubeless PCNL in complex cases, including pediatric, geriatric, and bilateral simultaneous procedures.^(28,29) The reduced length of hospitalization is a major cost-saving advantage, allowing for the reallocation of limited healthcare resources. Bechis et al. reported the largest U.S. series of outpatient PCNL, suggesting its reproducibility and feasibility, and described it as a potential "trifecta win" for patients, providers, and health systems.⁽³⁰⁾ Recent studies by Zhao et al., Gao et al., and Gassmann et al. further support that day-care PCNL is more cost-effective than inpatient PCNL, with no significant difference in complication rates.⁽⁴²⁻⁴⁴⁾

A new study by Rosen et al. demonstrated that PCNL can be safely performed in an ambulatory surgical center for most patients, including those with higher-risk profiles, though staghorn calculi emerged as a significant predictor of hospital transfer.⁽⁴⁵⁾ The recent meta-analysis by Calvillo-Ramirez et al. provides strong evidence supporting the safety and feasibility of day-case PCNL, showing reduced blood loss, shorter operative times, and significant cost savings.⁽⁴⁶⁾

Ambulatory PCNL is feasible for both optimal and select suboptimal candidates, broadening its applicability. However, additional high-quality studies are needed to refine patient selection, evaluate long-term outcomes, and enhance protocols. A uniform adoption of a common assessment tool for stone complexity would facilitate risk adjustment and comparison of outcomes in multicenter studies. It is hoped that this systematic review will stimulate debate among practitioners and researchers toward a future consensus on the feasibility of outpatient PCNL.

CONCLUSIONS

Ambulatory PCNL is a safe and effective option for managing kidney stones in highly selected patients. Ideal candidates are those with an ASA score < 3, BMI < 35 kg/m², minimal comorbidities, and a low stone burden. Strict preoperative, intraoperative, and postoperative criteria, such as stable hemodynamics and effective pain control, are essential for success. The procedure offers high stone clearance rates, low complications, and reduced healthcare resource use. Standardized protocols and further studies are needed to refine patient selection and expand its applicability, ensuring optimal outcomes and healthcare efficiency.

SUMMARY

For select patients, same-day percutaneous kidney stone surgery (PCNL) is safe and effective. This minimally invasive approach has high success rates and low complications, saving hospital resources and allowing patients to recover at home sooner.

CONFLICT OF INTEREST

No competing financial interests exist.

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