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Review Article

Review of efficacy and safety of same-day discharge after percutaneous nephrolithotomy

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Abstract: Purpose: Prior literature reviews have assessed the efficacy and safety of outpatient percutaneous nephrolithotomy (PCNL) with "outpatient" defined as discharge within twenty-four hours of surgery. To our knowledge, this is the first literature review analyzing ambulatory PCNLs (aPCNL) defined as hospital discharge on the same day as surgery. This review aims to assess the efficacy and safety of same-day discharge after PCNL. Methods: We conducted a search in the PubMed database for key search terms including "ambulatory PCNL", "ambulatory percutaneous nephrolithotomy", "outpatient PCNL", "outpatient percutaneous nephrolithotomy", and "day surgery percutaneous nephrolithotomy". We reviewed articles defining "ambulatory" as discharge the same day the PCNL was performed. 13 papers were identified in our search. Results: Overall, we found no difference in complication rates, emergency department visits, and postoperative admissions when comparing outpatient PCNL to inpatient PCNL, and to previously published statistics for inpatient PCNL. Some studies even showed lower rates of adverse outcomes in ambulatory cohorts when compared to inpatient cohorts. Additionally, ambulatory PCNL conferred significant healthcare savings over inpatient PCNL. Conclusion: This literature review suggests that ambulatory PCNL can be safely performed in both optimal and suboptimal surgical candidates with no significant increase in complications. Additional high-quality studies are warranted to further the evidence surrounding outpatient PCNL and its outcomes.

Keywords: Urolithiasis, nephrolithiasis, percutaneous nephrolithotomy, ambulatory, same day discharge, PCNL, day surgery

Introduction

Humble beginnings to a revolutionary procedure

Percutaneous nephrolithotomy (PCNL) was first described as a treatment modality for nephrolithiasis in 1976 by Fernstrom and Johansson [1]. They detailed three cases of their novel technique, consisting of gaining percutaneous access to the kidney, placing a nephrostomy tube, and dilating the tract by increasing the size of the Couvelaire catheter daily. Once sufficiently dilated, the tract was allowed to mature for at least two weeks before stone removal [1]. The success of this percutaneous approach laid the groundwork for a minimally invasive surgical technique that would go on to replace open stone surgery and become a standard of care in urological management of large renal stones.

Five years later, Alken et al. published a case series on their experience with percutaneous stone manipulation in thirty-eight patients [2]. This report expanded on Fernstrom's initial PCNL technique, incorporating disintegration by lithotrites and chemolysis of stones that were too large to be removed from the nephrostomy hole [2]. Postoperative hospitalization time for these 38 cases ranged from four to thirty days [2]. Similarly, Clayman et al. shared the results of the first one hundred PCNL cases they performed from 1979 to 1982 [3]. In sixty-nine cases, removal of stones the same day as obtaining percutaneous renal access was attempted but not possible, leading the patients to wait another 2-4 days for maturation of the tract before stone removal [3]. At this point in time, patients were being hospitalized for an average of 8.1 days and those with larger stones often stayed for 12 days to undergo two

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to three sessions of PCNL and clear all of the stone [3].

Additionally, they saw a sizable complication rate of 41-43% [3]. This was not outside the norm for that era. A retrospective study analyzed the outcomes of PCNL alone, extracorporeal shock-wave lithotripsy (ESWL) alone, and PCNL and ESWL combined in a cohort of patients who underwent stone treatment from 1983 to 1987 [4]. There was found to be a 49% complication rate in those who underwent PCNL compared to a 24.5% complication rate in those who underwent ESWL [4]. As technology has evolved and surgeons' skills have been honed, the incidence of postoperative issues has decreased significantly, and in a large worldwide study performed in 2011, the complication rate after PCNL was found to be 20.5% [5]. This study of over 5,000 patients found a transfusion rate of 5.7% [5], a considerable difference from the transfusion rates of 14.2-23% published by studies of percutaneous nephrolithotomies undergone in the 1980s and 1990s [6, 7].

Pushing the limit

PCNL has evolved over the past four and a half decades into a procedure that can be feasibly performed on an outpatient basis. The first report of outpatient PCNL was a case series published by Preminger et al. in 1986 [8]. They described five cases of healthy young men with singular stones and average stone size <1 cm who underwent PCNL with same-day discharge and had no reported complications [8]. While the procedure was performed on an outpatient basis, the patients followed up in clinic the next day, underwent a nephrostogram, and had their nephrostomy tube removed if deemed appropriate [8]. Nonetheless, this study exemplified the safety and efficacy of outpatient PCNL even in the immediate years following its birth.

While prior reviews have assessed the efficacy and safety of outpatient PCNL, these reviews defined "outpatient" as discharge within twenty-four hours of surgery [9, 10]. To our knowledge, this is the first review of the literature surrounding ambulatory PCNL defined as hospital discharge on the same day as surgery [9, 10]. Previously published reviews and meta-analyses have used a broader definition of "ambulatory" and included studies that discharged patients the day after surgery [9, 10]. Herein, we aim to review the literature describing the efficacy and safety of same-day discharge following percutaneous nephrolithotomy.

Methods

We conducted a search in the PubMed database for key search terms including "ambulatory PCNL", "ambulatory percutaneous nephrolithotomy", "outpatient PCNL", "outpatient percutaneous nephrolithotomy", and "day surgery percutaneous nephrolithotomy". We reviewed articles defining "ambulatory" as discharge the same day the PCNL was performed (i.e., no overnight stays). 13 papers (one prospective randomized control trial (RCT), one prospective cohort study, six retrospective studies, two case series, and three case reports) were identified in our search. We aimed to review safety outcomes (complications, emergency department (ED) visits, and postoperative admissions) and cost effectiveness of ambulatory PCNL (aPCNL).

Results and discussion

Optimal candidacy

Many of the analyzed studies published the criteria they used to decide who was a candidate for outpatient PCNL. Commonly used preoperative inclusion criteria were age greater than 18 years old, body mass index (BMI) less than 30-35 kg/m^2, American Society of Anesthesiologists (ASA) score less than 3, and no indwelling preoperative ureteral stent or nephrostomy tube. Active cardiac disease, solitary kidney, and renal insufficiency (serum creatinine 1.2 mg/dL or greater) were utilized as preoperative exclusion criteria in multiple studies. Social guidelines such as the patient living in proximity to the hospital and having adequate family support were highly considered when deciding eligibility for aPCNL. Intraoperative exclusion criteria included 3 or more punctures needed to obtain access to the collecting system, pelvicalyceal injury, significant intraoperative bleeding, and residual stone burden. Postoperatively, abnormal chest radiograph, need for transfusion, fever, hemodynam-

ic instability, and pain uncontrolled by oral medications were deemed adequate reasons to justify an overnight stay or admission [11-19].

A majority of the reviewed papers used many of these aforementioned guidelines, leading their optimal candidate for outpatient PCNL to be of a very specific population. However, a retrospective study published by Hosier et al. reported 92 of their ambulatory PCNL cases that pushed the boundaries by using less strict inclusion/exclusion criteria [11]. They included patients with one or more of the "extended criteria": BMI >30 kg/m^2, ASA score >2 (45% were ASA 3 or greater), age >75 years old, pre-existing nephrostomy tubes or stents, solitary kidney, transplant kidney, stone burden >40 mm, bilateral stone burden, complete staghorn stones, and multiple tracts [11]. Additionally, they compared outcomes of this "extended criteria" group (92 patients) to that of a "standard criteria" group which included 26 patients who underwent PCNL but did not meet any of the extended criteria. They found no significant differences in complication rates (18% vs. 12%), postoperative ED visits (18% vs. 12%), and readmissions (5% vs. 4%) between the extended criteria and standard criteria cohorts, respectively [11]. This study is critical in demonstrating that same-day discharge after PCNL can be safely implemented in a larger population of patients including the elderly and those with multiple comorbidities.

Safety outcomes

With the technological advancement of tools utilized intraoperatively and refinement of surgeon expertise over the years, PCNL has become a routinely used procedure that can be performed safely. Nonetheless, like any surgery, safety outcomes are a major concern amongst many urologists especially when considering same-day discharge after PCNL. The most commonly assessed safety outcomes are complication rate, postoperative emergency department (ED) visits, and rate of postoperative admission.

Complications: Twelve of the included studies commented on complications following ambulatory PCNL. In these twelve studies, the complication rates of outpatient PCNL ranged from 0-20% [11-22]. This is in line with the overall PCNL complication rate of 20.5% found in the widely referenced Clinical Research Office of the Endourological Society (CROES) Percutaneous Nephrolithotomy Global Study - a worldwide, multi-center analysis of more than five-thousand patients who underwent percutaneous nephrolithotomy [5]. Four of the five studies found that all of their reported complications after aPCNL were low-grade, Clavien I and II [12-15]. The fifth study, a retrospective review of 500 ambulatory PCNL cases published by Chong et al., did not collect information on Clavien I complications, as they deemed that it was difficult to accurately capture all Clavien I complications in the outpatient setting [20]. However, they reported a 2.4% rate of Clavien II-IV complications, lower than the 9.43% rate of complications of the same severity found in the CROES study [5, 20]. Of the remaining studies that did not classify their complications in terms of the Clavien-Dindo system, minor complications such as fever, stent colic, flank pain, mild-moderate hematuria, and urinary tract infection were most commonly seen [11, 16-18] (**Table 1**). Of the 146 aPCNL patients in Fahmy et al.'s study, there was one report of arterial pseudoaneurysm and one report of severe postoperative hematuria [17]. Hosier et al. analyzed 118 cases of ambulatory PCNL and saw one case of non-ST-elevation myocardial infarction [11]. While these complications are serious and life-threatening, their prevalence seen in these two studies concurs with that reported by the CROEs study for Clavien III-IV complications [5].

Four of the studies in our analysis compare the complication rate of ambulatory PCNL to that of standard PCNL (sPCNL) (admitted/observed at least one night) [12, 14, 17, 18]. Three of the aforementioned studies are retrospective reviews, and all found lower complication rates in the ambulatory PCNL group than the inpatient PCNL group [12, 14, 17] (**Table 1**). However, these retrospective studies did not comment on the statistical significance of the differences in complication rates. In contrast, the fourth aforementioned study, published by Kumar et al., was conducted as a prospective randomized control trial [18]. A total of 113 patients were randomly assigned to either tubeless ambulatory PCNL with a hemostatic seal (Group 1;

Table 1. Complication rates

Study	Study Type	Sample Size	Study Period	aPCNL complication rate	Complications	sPCNL complication rate	*p*-value
Hosier et al. [11] (34812729)	Retrospective	118 (92 extended criteria, 26 standard criteria)	2007-2018	17% (18% extended, 12% standard, P=0.56)	Stent colic (10), hematuria (1), urinary retention (4), UTI (1), cellulitis (1), pyelonephritis (1), pleural effusion (1), NSTEMI (1)	N/A	N/A
Chong et al. [20] (34036805)	Prospectively collected, retrospectively analyzed	500 cases (12 transferred to hospital, 2.4%)	2015-2019	2.4% (*didn't report Clavien I complications*)	Clavien II (4), Clavien III (3), Clavien IV (5)	N/A	N/A
Schoenfeld et al. [12] (30489147)	Prospective	47 cases (47 sPCNL in control)	2014-2016	8.5%	Clavien I (4)	17% (Clavien II (6), Clavien III (2))	N/A
Beiko et al. (2015) [13] (25221917)	Retrospective	50 patients/52 renal units	2007-2013	18%	Clavien I (6) (stent colic (4), extruded ureteral stent (1), ovarian vein thrombosis (1)), Clavien II (3) (DVT (1), UTI (1), cellulitis (1))	N/A	N/A
Shahrour, Andonian [16] (21130245)	Case series	10 cases	2009	20%	UTI requiring IV antibiotics (1), DVT (1)	N/A	N/A
Bechis et al. [14] (29634376)	Retrospective	43 same day discharge (d/c), 27 overnight (o/n) stay, 37 inpatient	2015-2016	18.6%	Clavien I (3) (gross hematuria (1), drainage from access site (2)), Clavien II (5) (pyelonephritis (1), sepsis (1), UTI (3))	Overnight: 23.5%, Inpatient: 27%	0.43 (same day d/c + o/n VS. inpatient), 0.67 (same day d/c VS. o/n)
Fahmy et al. [17] (28275511)	Retrospective	146 same day d/c, 16 inpatient	2011-2014	13.7%	Flank pain (12), mild-moderate hematuria (3), severe hematuria (1), fever (2), arterial pseudoaneurysm (1), pyelonephritis (1)	25%	
Beiko et al. (2010) [19] (20694090)	Case series	3 cases		0%	None	N/A	N/A
Kokorovic et al. [21] (24839499)	Case report	1 case		0%	None	N/A	N/A
Beiko et al. (2009) [22] (19478955)	Case report	1 case		0%	None	N/A	N/A
Kumar et al. [18] (27551557)	Prospective RCT	56 day-surgery with seal, 57 inpatient with tube	2014-2015	19.6%	Fever (5), urine leak from wound (2), UTI (2), tract site abscess (3)	47.4%	<0.05
Lee et al. [15] (34663076)	Retrospective cohort	23 aPCNL, 19 sPCNL	2020	4.3%	Clavien I (1)	21.1%	0.377

n=56) or inpatient PCNL with placement of a nephrostomy tube (Group 2; n=57) [18]. They found a significant difference in the complication rates between Groups 1 and 2, with rates being 19.6% and 47.4%, respectively (P<0.05) [18]. All complications in the ambulatory group were Clavien I-III with the majority being fever [18]. It cannot be ignored that there are more variables acting in this study than just length of stay in the hospital (i.e., hemostatic seal vs. nephrostomy tube) that may account for some of the complications. Even so, the ambulatory PCNL complication rate (19.7%) is consistent with the overall PCNL complication rate found by the large CROES study, suggesting that performing percutaneous nephrolithotomy as an outpatient procedure does not confer any increased risk of postoperative complications than standard PCNL with postoperative hospital admission [5]. An important point was made by Fahmy et al. in their discussion of complications after PCNL. They highlighted that routine hospitalization of patients after PCNL may very well lead to complications such as hospital-acquired infection that can be avoided with same-day discharge, all the more reason for consideration of outpatient PCNL [17].

When reported, studies of aPCNL saw very low rates of transfusion. In Chong's study of 500 ambulatory PCNLs, they saw a transfusion rate of a mere 0.8% [20]. Two small case series of PCNL of ten and three patients both had no patients requiring transfusion during or after their surgeries [16, 19]. Additionally, two of the four studies that compared transfusion rates of ambulatory PCNL and inpatient PCNL had no patients requiring blood products [14, 15]. Fahmy et al. and Kumar et al. found less patients needing transfusion in the outpatient cohort than the inpatient cohort (25% vs. 0% (P<0.001), and 1.8% vs. 7% (P=0.36), respectively) [17, 18]. Of note, Kumar's study saw a significant difference in stone diameter, number of patients with ASA scores of 2 or 3, and BMI between the ambulatory and inpatient groups. These three parameters were all significantly greater in the inpatient group [18]. These studies made clear that same day discharge does not increase the likelihood of a patient having a bleeding complication requiring transfusion.

ED visits: Of the 13 included studies, nine reported on emergency department (ED) visit rates postoperatively. ED visits ranged from 0-18.6% [11-15, 17, 19, 21, 22] (**Table 2**). Four of these studies compared ambulatory PCNL to inpatient PCNL in terms of postoperative ED visits. Two of the four found an increased rate of ED visits in the ambulatory group but the differences were not statistically significant [12, 15]. Bechis et al. performed a retrospective review of PCNL cases at one tertiary care kidney stone center [14]. They looked at three separate groups of patients: patients who were discharged on the same day as their surgery (ambulatory), patients who stayed for overnight observation, and patients who were admitted for longer than one night postoperatively [14]. In terms of postoperative visits to the ED, they found nearly identical rates in inpatient (19%), ambulatory (19%), and overnight observation (18%) PCNL groups [14]. There was no significant difference in ED visits when comparing outpatient to overnight stay (P=0.93), and in comparing outpatient and overnight stay groups to the inpatient group (P=0.94) [14]. However, the groups did slightly differ in their baseline characteristics. Compared to the inpatient group, the ambulatory group had a greater presence of hydronephrosis, lower estimated blood loss, lower preoperative urine white blood cells, higher preoperative hemoglobin and hematocrit, less frequent access above the 12th rib, and less frequently required two or greater punctures to obtain access [14]. When compared to the ambulatory group, the overnight group had a higher incidence of hyperlipidemia and a lower preoperative hemoglobin [14]. Another retrospective study done by Fahmy et al. compared inpatient to ambulatory percutaneous nephrolithotomy and found less ED visits in the ambulatory group but did not analyze the significance of this difference [17]. Though the statistical analyses in some of these studies were incomplete, the aforementioned findings further support the safety of ambulatory PCNL with no significant differences seen in postoperative emergency department visits when compared to inpatient PCNL.

Postoperative admissions: Another important safety outcome to consider in patients undergoing outpatient PCNL is the rate of postoperative admissions. This parameter was described by twelve of the studies included in this review. Postoperative admission rates ranged from 0-11.6% [11-22]. Commonly cited reasons for postoperative admissions after ambulatory

Table 2. Emergency department visits

Study	Study Type	Sample Size	Study Period	% ED visits (aPCNL)	% ED visits (sPCNL)	*p*-value
Hosier et al. [11] (34812729)	Retrospective	118 (92 extended criteria, 26 standard criteria)	2007-2018	16.9% (12% standard, 18% extended, P=0.56)	N/A	N/A
Schoenfeld et al. [12] (30489147)	Prospective	47 cases (47 sPCNL in control)	2014-2016	11%	9%	0.76
Beiko et al. (2015) [13] (25221917)	Retrospective	50 patients/52 renal units	2007-2013	12%	N/A	N/A
Bechis et al. [14] (29634376)	Retrospective	43 same day d/c, 27 o/n stay, 37 inpatient	2015-2016	18.6%	Overnight stay: 18%, Inpatient: 18.9%	Overnight + outpatient vs. inpatient: P=0.94; overnight vs. outpatient: P=0.93
Fahmy et al. [17] (28275511)	Retrospective	146 same day d/c, 16 inpatient	2011-2014	3.4%	12.5%	N/A
Beiko et al. (2010) [19] (20694090)	Case series	3 cases		0%	N/A	N/A
Kokorovic et al. [21] (24839499)	Case report	1 case		0%	N/A	N/A
Beiko et al. (2009) [22] (19478955)	Case report	1 case		0%	N/A	N/A
Lee et al. [15] (34663076)	Retrospective cohort	23 aPCNL, 19 sPCNL	2020	13.6%	10.5%	0.762

PCNL were of infectious origin. This included pyelonephritis, urinary tract infection (UTI) requiring intravenous (IV) antibiotics, tract site abscess, and sepsis [11, 13, 14, 17, 18, 20]. In large retrospective analysis of five-hundred outpatient PCNLs by Chong et al., 1% of patients were postoperatively admitted for intubation due to respiratory failure and another 0.6% of patients were admitted for management of arterial pseudoaneurysm [20]. Fahmy et al. also saw one admission for postoperative pseudoaneurysm in their cohort of 146 patients undergoing aPCNL (0.68% incidence) [17]. In comparing the postoperative admission/readmission rates between ambulatory and inpatient PCNL, no significant differences were found by the five studies that measured this parameter [12, 14, 15, 17, 18] (**Table 3**). Additionally, a previously published meta-analysis by Jones et al. analyzed the outcomes of discharge within 24 hours of PCNL and found no significant difference in postoperative admission rates when comparing same-day discharge to next-day discharge [10]. Altogether, the results of these studies show that monitoring patients in the hospital for a longer time postoperatively does not prevent readmissions or decrease complication rates.

Cost

A significant potential advantage of outpatient procedures is the decreased cost when compared to inpatient surgery. In 2018, Kroczak et al. published an analysis of the difference in cost between ambulatory and inpatient PCNL in Canada [23]. It was assumed that the cost for the surgical procedure, cost of anesthesia, cost of the physician, operative time, and perioperative imaging were the same for inpatient and outpatient PCNL [23]. It was also assumed that postoperative safety outcomes (i.e., complication rates, ED visits) were identical between the two groups. The authors calculated the cost savings of ambulatory PCNL to be $3348 per case - the cost of the average hospital stay of 4.19 days for inpatient PCNL [23]. This indicates a significant cost reduction of 34.6% per case [23].

Similarly, Lee et al. performed a cost analysis of a cohort of patients who underwent PCNL at a tertiary referral center in the United States (US), comparing the expenses of outpatient and inpatient procedures [15]. They found that for the surgery itself, inpatient PCNL cost $2929 ± 832 ($P<0.0001$) more than ambulatory PCNL [15]. For unplanned care episodes, there was a cost difference of $4442 ± 4811 ($P=0.368$), with inpatient PCNL again causing a greater expense to the hospital [15]. Overall, it was determined that aPCNL allowed for $5327 ± 442 ($P<0.0948$) in cost savings per case when compared to inpatient PCNL [15]. The case for aPCNL is strongly supported by the clear reduction of healthcare spending and resource usage that results from outpatient surgery.

Future studies

A majority of the papers included in our review of the literature are retrospective cohort studies, case series, and case reports. Higher quality studies such as prospective cohort studies and randomized control trials are warranted to provide further assessment of ambulatory percutaneous nephrolithotomy and its outcomes. Additionally, there is an absence of data describing the patient perspective of same-day discharge after PCNL. Future studies should incorporate parameters such as the effect of same-day discharge on patients' quality of life, postoperative pain control, and satisfaction with the surgery when compared to inpatient surgery. These are incredibly important factors that should be prioritized when considering aPCNL.

Our optimal patient

While any patient can be considered for day surgery PCNL, there are several patients and procedural factors that favor admission. Our relative indications for someone who is not appropriate for same day discharge would be high risk of postoperative sepsis (for example, from a staghorn infective stone like struvite), severe comorbidities, extremes of age, and significant intraoperative blood loss or complication.

Conclusion

Ambulatory percutaneous nephrolithotomy was first described in the literature in 1986 and since its advent, has been growing in popularity with a number of papers reporting on its outcomes [8]. In our review of the literature of PCNL with same-day discharge, overall, we

Table 3. Postoperative admissions

Study	Study Type	Sample Size	Study Period	% Admissions (aPCNL)	Admission Reasons	% Readmissions (sPCNL)	*p*-value
Hosier et al. [11] (34812729)	Retrospective	118 (92 extended criteria, 26 standard criteria)	2007-2018	5% (5% extended, 4% standard, P=1)	Stent colic (1), hematuria (1), urinary retention (1), pyelonephritis (1), pleural effusion (1), NSTEMI (1)	N/A	N/A
Chong et al. [20] (34036805)	Prospectively collected, retrospectively analyzed	500 cases (12 transferred to hospital, 2.4%)	2015-2019	2.4% transferred to hospital postop; 4.2% readmission rate	Intubation for respiratory failure (5), embolization for pseudoaneurysm (3), UTI requiring IV antibiotics (?), anemia requiring transfusion (?)	N/A	N/A
Schoenfeld et al. [12] (30489147)	Prospective	47 cases (47 sPCNL in control)	2014-2016	2%	Supportive care for pain and subjective fever (1)	6%	0.62
Beiko et al. (2015) [13] (25221917)	Retrospective	50 patients/52 renal units	2007-2013	4%	MDR E. Coli requiring IV Abx (1), pain control for stent colic (1)	N/A	N/A
Shahrour, Andonian [16] (21130245)	Case series	10 cases	2009	10%	UTI requiring IV antibiotics (1)	N/A	N/A
Bechis et al. [14] (29634376)	Retrospective	43 same day d/c, 27 o/n stay, 37 inpatient	2015-2016	11.6%	Sepsis (1), pyelonephritis (1), drainage from access site (1), acute renal insufficiency (1), nephrostomy tube upsizing (1)	Overnight: 6%, Inpatient: 3%	Outpatient vs. overnight: P=0.26; Overnight + outpatient vs. inpatient: P=0.057
Fahmy et al. [17] (28275511)	Retrospective	146 same day d/c, 16 inpatient	2011-2014	1.2%	Pseudoaneurysm (1), pyelonephritis (1)	0%	N/A
Beiko et al. (2010) [19] (20694090)	Case series	3 cases		0%	None	N/A	N/A
Kokorovic et al. [21] (24839499)	Case report	1 case		0%	None	N/A	N/A
Beiko et al. (2009) [22] (19478955)	Case report	1 case		0%	None	N/A	N/A
Kumar et al. [18] (27551557)	Prospective RCT	56 day-surgery with seal, 57 inpatient with tube	2014-2015	7.1%	Tract site abscess (3), hematuria (1)	1.8%	0.21
Lee et al. [15] (34663076)	Retrospective cohort	23 aPCNL, 19 sPCNL	2020	0%	None	5.3%	0.276

found no difference in safety outcomes including complication rates, emergency department visits, and postoperative admissions, when compared to inpatient PCNL and previously published statistics for PCNL. This conclusion is consistent with a previously published meta-analysis by Jones et al. that found no significant difference in complication rates between same-day and next-day discharge after PCNL [10]. Some studies even found lower rates of adverse outcomes in ambulatory cohorts when compared to inpatient cohorts. It was demonstrated by one paper that outpatient PCNL can even be safely performed, with no difference in complications, in less-than-optimal surgery candidates [11]. In regard to cost, it is overwhelmingly clear that outpatient PCNL confers significant healthcare savings over inpatient PCNL due to the obvious decreased use of hospital resources, as supported by more than one formally conducted study [15, 23]. Future studies, preferably prospective analyses and randomized control trials, are warranted to enhance the evidence surrounding outpatient PCNL and its outcomes.

Disclosure of conflict of interest

None.

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References

[1] Fernstrom I and Johansson B. Percutaneous pyelolithotomy. A new extraction technique. Scand J Urol Nephrol 1976; 10: 257-259.

[2] Alken P, Hutschenreiter G, Gunther R and Marberger M. Percutaneous stone manipulation. J Urol 1981; 125: 463-466.

[3] Clayman RV, Surya V, Miller RP, Castaneda-Zuniga WR, Smith AD, Hunter DH, Amplatz K and Lange PH. Percutaneous nephrolithotomy: extraction of renal and ureteral calculi from 100 patients. J Urol 1984; 131: 868-871.

[4] Gleeson M, Lerner SP and Griffith DP. Treatment of staghorn calculi with extracorporeal shock-wave lithotripsy and percutaneous nephrolithotomy. Urology 1991; 38: 145-151.

[5] de la Rosette J, Assimos D, Desai M, Gutierrez J, Lingeman J, Scarpa R and Tefekli A; CROES PCNL Study Group. The Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study: indications, complications, and outcomes in 5803 patients. J Endourol 2011; 25: 11-17.

[6] Stoller ML, Wolf JS Jr and St Lezin MA. Estimated blood loss and transfusion rates associated with percutaneous nephrolithotomy. J Urol 1994; 152: 1977-1981.

[7] Rodrigues Netto N Jr, Lemos GC, Palma PC and Fiuza JL. Staghorn calculi: percutaneous versus anatrophic nephrolithotomy. Eur Urol 1988; 15: 9-12.

[8] Preminger GM, Clayman RV, Curry T, Redman HC and Peters PC. Outpatient percutaneous nephrostolithotomy. J Urol 1986; 136: 355-357.

[9] Gao M, Zeng F, Zhu Z, Zeng H, Chen Z, Li Y, Yang Z, Cui Y, He C, Chen J and Chen H. Day care surgery versus inpatient percutaneous nephrolithotomy: a systematic review and meta-analysis. Int J Surg 2020; 81: 132-139.

[10] Jones P, Bennett G, Dosis A, Pietropaolo A, Geraghty R, Aboumarzouk O, Skolarikos A and Somani BK. Safety and efficacy of day-case percutaneous nephrolithotomy: a systematic review from European Society of Uro-technology. Eur Urol Focus 2019; 5: 1127-1134.

[11] Hosier GW, Visram K, McGregor T, Steele S, Touma NJ and Beiko D. Ambulatory percutaneous nephrolithotomy is safe and effective in patients with extended selection criteria. Can Urol Assoc J 2022; 16: 89-95.

[12] Schoenfeld D, Zhou T and Stern JM. Outcomes for patients undergoing ambulatory percutaneous nephrolithotomy. J Endourol 2019; 33: 189-193.

[13] Beiko D, Elkoushy MA, Kokorovic A, Roberts G, Robb S and Andonian S. Ambulatory percutaneous nephrolithotomy: what is the rate of readmission? J Endourol 2015; 29: 410-414.

[14] Bechis SK, Han DS, Abbott JE, Holst DD, Alagh A, DiPina T and Sur RL. Outpatient percutaneous nephrolithotomy: the UC San Diego health experience. J Endourol 2018; 32: 394-401.

[15] Lee MS, Assmus MA, Agarwal DK, Rivera ME, Large T and Krambeck AE. Ambulatory percutaneous nephrolithotomy may be cost-effective compared to standard percutaneous nephrolithotomy. J Endourol 2022; 36: 176-182.

[16] Shahrour W and Andonian S. Ambulatory percutaneous nephrolithotomy: initial series. Urology 2010; 76: 1288-1292.

[17] Fahmy A, Rhashad H, Algebaly O and Sameh W. Can percutaneous nephrolithotomy be performed as an outpatient procedure? Arab J Urol 2017; 15: 1-6.

[18] Kumar S, Singh S, Singh P and Singh SK. Day care PNL using 'Santosh-PGI hemostatic seal' versus standard PNL: a randomized controlled

study. Cent European J Urol 2016; 69: 190-197.
[19] Beiko D and Lee L. Outpatient tubeless percutaneous nephrolithotomy: the initial case series. Can Urol Assoc J 2010; 4: E86-90.
[20] Chong JT, Dunne M, Magnan B, Abbott J and Davalos JG. Ambulatory percutaneous nephrolithotomy in a free-standing surgery center: an analysis of 500 consecutive cases. J Endourol 2021; 35: 1738-1742.
[21] Kokorovic A, Wilson JW and Beiko D. Outpatient bilateral supracostal tubeless percutaneous nephrolithotomy for staghorn calculi. Can Urol Assoc J 2014; 8: E273-275.
[22] Beiko D, Samant M and McGregor TB. Totally tubeless outpatient percutaneous nephrolithotomy: initial case report. Adv Urol 2009; 2009: 295825.
[23] Kroczak T, Pace KT, Andonian S and Beiko D. Ambulatory percutaneous nephrolithotomy in Canada: a cost-reducing innovation. Can Urol Assoc J 2018; 12: 427-429.