Am J Clin Exp Urol 2021;9(6):497-503
www.ajceu.us /ISSN:2330-1910/AJCEU0137140

*Original Article*

# Analysis of surgical complications of percutaneous nephrolythotomy, in the first three years, in a teaching hospital

João Marcos I de Oliveira, Ivan B Selegatto, Gabriel C S Simoes, Arthur Degani Ottaiano, Wilmar Azal Neto, Leonardo O Reis

*UroScience, University of Campinas (Unicamp) and Pontifical Catholic University of Campinas (PU-Campinas), Campinas, São Paulo 13034-685, Brazil*

Received July 7, 2021; Accepted September 22, 2021; Epub December 15, 2021; Published December 30, 2021

**Abstract:** Purpose: To clarify the existing relationships between the characteristics of the patients and calculi and the rate of complications associated with contemporary percutaneous nephrolithotomy (PCNL). Methods: Retrospective cohort study of 126 consecutive patients who underwent PCNL at the academic medical center of the State Hospital of Sumaré-University of Campinas from 2016 to 2019. This study examined the correlation of pre-existing comorbidities and calculi characteristics with the incidence of postoperative complications. Results: 72 (57.14%) needed complementary procedure for the residual stone fragments (defined as fragments size >3 mm). Complications occurred in 28 patients (22.22%). Of the patients who did not present any complications (n=98, 77.77%), 61 (62.24%) stayed in the hospital for 1-3 days. The length of hospital stays significantly correlated with higher grade of complication (P=0.018). Grade III staghorn calculi demonstrated a greater number of residual stone fragments (P<0.001). In this group of staghorn calculi (n=27, 21.42%), 24 (88.88%) presented with residual stone fragments after the PCNL procedure (P<0.001). Conclusions: PCNL complications are related to longer hospital stay and calculus complexity is directly related to the rate of residual stone fragments, especially in cases of grade III staghorn calculi.

**Keywords:** Nephrolithiasis, percutaneous nephrolithotomy, complications

## Introduction

The prevalence of renal lithiasis has greatly increased in recent years, having doubled in the United States of America from that in the year 1960 [1, 2]. The consequent increase in the number of interventions led to the development of new minimally invasive methods and establishment of the role of percutaneous nephrolithotomy (PCNL) for larger, more complex calculi [1-4].

Staghorn calculi usually present a rapid progression in size and may involve the calyces and the entire renal pelvis within weeks or months. Without appropriate treatment, this condition can lead to deterioration of the kidney function, and consequently, a terminal kidney disease. Hence, most patients require definitive surgical treatment [4]. The surgical treatment alternatives for these calculi include open surgery, laparoscopy, PCNL, and a combination of PCNL and ureteroscopy (URS). PCNL is the most commonly used treatment, except in patients contraindicated for surgery or in those who refuse to remove the stones.

PCNL was initially described in 1970 as a form of minimally invasive treatment for the removal of kidney stones, which were previously treated only with open surgery [5]. Although it has proven to be an effective technique, the introduction of extracorporeal shock wave lithotripsy (ESWL) in the early 1980s [6] rapidly resulted in PCNL becoming obsolete.

Over time, the clinical experience with ESWL revealed its limitations [7, 8] when treating larger calculi, and treatment with PCNL was reinstated [5]. Today, it is considered the first line of treatment for large stones (>2 cm). On the other hand, URS presents significant limitations [2, 9, 10].

Furthermore, innovations in instruments (nephroscopes and ureteroscopes) and lithotripsy technology (ultrasonic, pneumatic, and laser) have increased the efficiency of percutaneous stone disintegration, achieving a stone-free rate above 90% [2, 11]. One of the indisputable advantages of PCNL is that if one stone can be reached, it can usually be removed. A direct inspection of the collecting system and the removal of fragments is a relatively quick procedure whose success or failure can be identified immediately.

The current study aimed to clarify the existing relationships between the characteristics of the patients and calculi and the rate of complications associated with contemporary percutaneous nephrolithotomy (PCNL).

## Methods

Retrospective, observational (non-interventional) study to describe consecutive patients, diagnosed with renal lithiasis by non-contrast abdominal computed tomography scan, who had undergone PCNL at the State Hospital of Sumaré (HES)-University of Campinas between March 2016 and March 2019.

In the studied period, 126 consecutive patients diagnosed with renal lithiasis who had undergone PCNL were included. The left kidney was affected in 62 cases and right kidney in 64 cases.

*Sampling and data collection and analysis*

After Research Ethics Committee approval and patients consent, data were obtained from patients' electronic medical records, and the variables were plotted in Microsoft Excel® 2018 for analysis. Outpatient consultations before and after the procedure were also analyzed to assess the clinical progress, interrogating about pain, hematuria, low urinary tract symptoms (LUTS) and upper urinary tract symptoms. The collected data regarding patient and stone characteristics were analyzed anonymously in groups to ensure the participants' anonymity and confidentiality throughout the study period. The groups were divided according to the grade of complication, and its correlation with the calculi location, presence of comorbidities, age, days of hospitalization, gender, and presence of residual stone fragments.

Statistical analysis was performed using Fisher's exact test for categorical variables and Mann-Whitney or Brunner Munzel test for continuous variables.

To standardize the reports of PCNL complications, the original Clavien-Dindo classification was adjusted to correlate with the PCNL complications by classifying them into five groups [12-14], as shown in **Table 1**.

*Inclusion criteria:* Consecutive patients diagnosed with renal lithiasis and treated by PCNL in the HES-University of Campinas between March 2016 and March 2019.

*Exclusion criteria:* Patients diagnosed with renal calculi that were not treated or were treated with other methods; patients that did not undergo non-contrast abdominal computed tomography scan.

## Results

The patients were divided by the grade of complication, and its correlation with the calculi location, presence of comorbidities, age, days of hospitalization, gender, and presence of residual stone fragments. The sex distribution showed female predominance (n=89, 70.6%), and the mean age during diagnosis was 51.63±14.1 years (range: 21-84 years). Among the patients who underwent PCNL, those with comorbidities represented the largest group (n=84, 66.67%). The comorbidities group was sub-divided into those with diabetes mellitus (DM) (n=17, 13.49%); cardiovascular diseases, which included systemic arterial hypertension, acute myocardial infarction (AMI), congestive heart failure, and dyslipidemia (n=52, 41.27%); smoking habit (n=14, 11.11%); and other comorbidities (n=21, 16.67%) (**Table 2**).

Among 126 included patients, 36 (28.57%) presented with grade I staghorn calculi, 27 (21.43%) with grade II staghorn calculi, 27 (21.43%) with grade III staghorn calculi, 21 (16.67%) with calculi located in the renal pelvis, 2 (1.59%) with calculi located in the superior calyx, 4 (3.17%) with calculi located in the middle calyx, and 9 (7.14%) with calculi located in the inferior calyx. Complementary procedures (PCNL, URS, or ESWL) for residual stone fragments (defined as fragments of size >3 mm) were necessary in 72 (57.14%) patients.

**Table 1.** Modified Clavien-Dindo classification for percutaneous nephrolithotomy

| Grade | Definition |
|---|---|
| 0 | Normal postoperative period, no deviations from the expected course |
| I | Any deviation from the normal postoperative course that does not require pharmacological treatment (symptomatic only) or surgical, endoscopic, or radiological interventions (e.g., postoperative pain management with opioids, fever management without antibiotics, bleeding that does not require blood transfusions, and management of urine leakage without intervention) |
| II | Requires pharmacological treatment with drugs other than those allowed for grade I complications (e.g., antibiotics). Blood transfusions and parenteral nutrition are also included (e.g., bleeding that requires transfusions, symptomatic urinary tract infection that requires the use of antibiotics, and supraventricular tachycardia that requires antiarrhythmic medication). |
| III | Requires surgical, endoscopic, or radiological intervention |
| IIIa | Intervention not under general anesthesia (e.g., bleeding controlled with endoscopic agents, hemothorax drainage under local anesthesia, hydrothorax drainage under local anesthesia, management of ureteral obstruction with double-J stents without general anesthesia, and management of renal pelvis rupture with double-J stents or prolonged nephrostomy) |
| IIIb | Intervention under general anesthesia (e.g., bleeding controlled by angioembolization or nephrectomy and management of colon perforation with colostomy) |
| IV | Life-threatening complications that require admission in the intensive care unit |
| IVa | Single organ dysfunction |
| IVb | Multiple organ dysfunction |
| V | Death |

Complications occurred in 28 patients (22.22%) using the PCNL-modified Clavien-Dindo classification [12].

Grade I complication of the Clavien-Dindo classification was observed in 11 cases (8.73%), of which 7 (63.63%) presented with moderate bleeding that did not require the transfusion of red blood cell concentrates and 4 (36.36%) presented with urine leakage around the nephrostomy tube that was managed with conservative treatment.

Five cases (3.96%) presented Clavien-Dindo's grade II complication: 1 (20%) presented with unstable atrial flutter that was treated with medication and did not require hospitalization in the intensive care unit (ICU); 2 (40%) presented with significant retroperitoneal infiltration that was demonstrated by contrast media extravasation in the image and received conservative treatment that did not require an approach; 1 (20%) presented with moderate bleeding and required a transfusion of 2 units of red blood cell concentrates to control the hemoglobin level and stabilize the patient, but did not need to be transferred to the ICU; and 1 (20%) presented with deep vein thrombosis that was treated with anticoagulation therapy.

Seven (5.55%) patients presenting Clavien-Dindo's grade III complication were further divided into groups IIIa (n=6, 85.71%) and IIIb (n=1, 14.28%). Group IIIa included 2 cases (33.33%) presenting hydrothorax, which was resolved with thoracic drainage under local anesthesia; 2 (33.33%) presenting ureteral obstruction with refractory pain and acute renal failure that required the passage of a double-J stent for relief; and 2 (33.33%) presenting a rupture of the renal pelvis that was managed with the passage of a double-J stent, which remained in place for 8 weeks. The only patient (n=1; 100%) in group IIIb presented with severe bleeding due to vascular injury, which required the transfusion of 2 units of red blood cell concentrates and had to be transferred to the Clinics Hospital-UNICAMP, where the patient underwent renal artery embolization to control bleeding.

Patients with Clavien-Dindo's grade IV complication (n=5; 3.96%) were divided into groups IVa and IVb. The group IVa patients (n=4; 80%) presented with severe bleeding and required transfusion of red blood cell concentrates and were transferred to the ICU due to hemodynamic instability. The only patient in group IVb (n=1; 20%) was admitted to the ICU for septic shock and multiple organ failure and required orotracheal intubation and use of vasoactive drugs, along with transfusion of red blood cell concentrates and prolonged use of antibiotics.

**Table 2.** The demographic, clinical and stone characteristics of the patients

| Total no. patients | n=126 |
|---|---|
| Sex | |
| Male | 37 (29.4%) |
| Female | 89 (70.6%) |
| Age (mean ± standard deviation) | 51.63±14.1 (21-84 years) |
| Comorbidities | 84 (66.67%) |
| Diabetes mellitus | 17 (13.5%) |
| Cardiovascular diseases | 52 (41.2%) |
| Smoking habit | 14 (11.1%) |
| Others | 21 (16.7%) |
| Calculus Location | |
| Grade I staghorn | 36 (28.57%) |
| Grade II staghorn | 27 (21.43%) |
| Grade III staghorn | 27 (21.43%) |
| Superior calyx | 2 (1.59%) |
| Middle calyx | 4 (3.17%) |
| Inferior calyx | 9 (7.14%) |
| Renal pelvis | 21 (16.67%) |
| Stone-free rate | |
| Residual stone fragments | 72 (57.14%) |
| No residual stone fragments | 54 (42.86%) |
| Length of hospital stay | |
| 1-3 days | 72 (57.14%) |
| >3 days | 54 (42.86%) |
| Classification of complications (Clavien-Dindo) | |
| 0 | 98 (77.78%) |
| I | 11 (8.73%) |
| II | 5 (3.97%) |
| IIIa | 6 (4.76%) |
| IIIb | 1 (0.79%) |
| IVa | 4 (3.17%) |
| IVb | 1 (0.79%) |
| V | 0 (0%) |

No patient in our study died; therefore, there were no patient's representative of grade V of the PCNL-modified Clavien-Dindo classification (n=0; 0%). The classification of the patients based on the grade of complication and its correlation with the calculi location, presence of comorbidities, age, days of hospitalization, sex, and presence of residual stone fragments indicated two statistically significant correlations.

The first statistically significant result was the relationship between the length of the hospital stay and the grade of complication, where patients who stayed in the hospital for more than 3 days showed a higher grade of complication (P= 0.018). Of the patients who did not present any complications (n=98, 77.77%), 61 (62.24%) stayed in the hospital for 1-3 days. In the groups with grade III (n=7, 5.55%) and grade IV (n=5, 3.96%) complications, 11 (91.66%) stayed in the hospital for more than 3 days (**Figure 1**).

The other statistically significant result was the relationship between calculus characteristics and the presence of residual stone fragments, where grade III staghorn calculi (occupies the renal pelvis and all calycinal groups) demonstrated a greater number of residual stone fragments (P<0.001). In this group of staghorn calculi (n=27, 21.42%), 24 (88.88%) presented with residual stone fragments after the PCNL procedure (P<0.001).

## Discussion

Percutaneous access for the treatment of renal lithiasis was proposed 30 years ago. Because of advances in the technique, PCNL has now replaced open surgery for the treatment of cases with complex kidney stones. The appropriate surgical technique is selected based on the imaging characteristics of the stones [4, 5].

The Clavien-Dindo classification of complications has been modified to group significant complications related to PCNL. Violette et al. used the well-established Clavien-Dindo classification system of complications to create a new system focused on the complications associated with PCNL. This new classification helps standardize the grouping of complications in order to facilitate analyses and provide a better understanding of the risks associated with PCNL. It supports comparisons of compli-

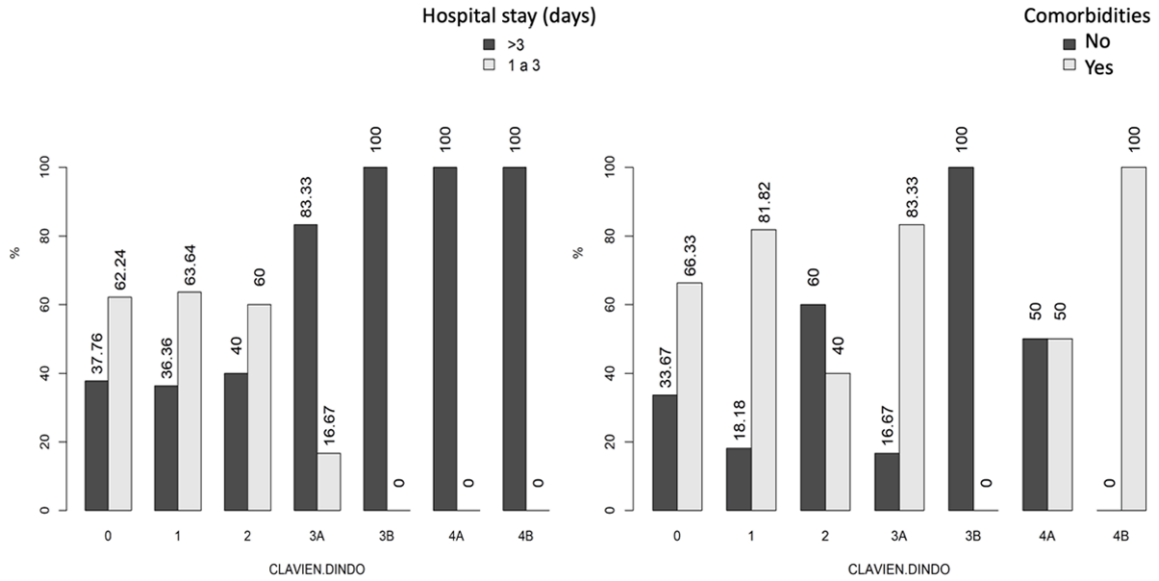


**Figure 1.** Correlation between Clavien-Dindo classification, hospital stay and comorbidities.

cations with a more objective pattern by separating each complication in a group with similar morbidity and mortality values. Hence, we used the modified Clavien-Dindo classification in our study to classify the PCNL complications [12].

A literature review by Taylor et al. [1], which included 5,803 patients who underwent PCNL, demonstrated a 21.5% rate of complications, a value similar to the one found in this study (22.22%). Pleural lesions were found in 0.3-1.0% of the cases in the former study, while our study observed pleural lesions in 1.58% of the cases. Transfusions due to bleeding were performed in 2.0-6.9% of the cases in the assessment by Taylor et al., as compared to 3.96% of the patients who underwent PCNL in our care unit. Intervention was required in less than 2% of the patients in the former review, while only 0.79% required intervention in our study. Only 2 (0.03%) patients with Clavien-Dindo's grade V complication were reported in the study by Taylor et al., and mortality was associated with complications secondary to pulmonary embolism, AMI, and severe sepsis. Complications demonstrated in our study are similar to those present in current literature.

In a study by Felici et al. [10], 100 patients undergoing PCNL were selected and classified according to the location and size of the kidney stones to determine the stone-free rate (residual stone fragments size ≤2 mm). The stone-free rate was significantly higher among patients with non-staghorn calculi. There was no statistical significance among patients with staghorn calculi, but a trend of larger and higher-grade staghorn calculi to a greater chance of residual stone fragments was observed. Our study showed a significant relationship between calculus characteristics and the presence of residual stone fragments ($P<0.001$), where grade III staghorn calculi were associated with a greater number of residual stone fragments. In patients with grade III staghorn calculi who underwent PCNL, Felici et al. [10] found residual fragments in 92.31% of the cases as compared to 88.88% (n=24) of the patients in our study.

Kallidonis et al. [15] conducted a review of the classification, management, and prevention of complications in patients undergoing PCNL. They stated that the risk factors for increased morbidity in this group of patients should be evaluated before the procedure and that the procedure should be avoided in patients with coagulopathy, urinary tract infection, or pyonephrosis. Comorbidities such as DM, complex anatomical changes, and horseshoe kidney were related to complications in the study by Kallidonis et al. However, this relationship did not show a statistical significance in our study ($P=0.37$). They also demonstrated that age above 55 years is an independent risk factor

for major complications, which was not proven in our assessment (P=0.381).

In 2008, Tefekli et al. [16] examined 811 cases and proposed an adaptation to the modified Clavien-Dindo classification for studies on PCNL complications. They correlated the severity of the complications with the complexity of the calculus but found no significant relationship. In our population analysis, we identified seven major complications (grades IIIa to IVb of the Clavien-Dindo classification) but detected no statistical significance in relation to calculus characteristics.

Khan et al. [17] correlated hospital costs and days of hospitalization with surgical complications in 7457 patients who underwent non-cardiac surgery, where 6.9% of these patients had at least one postoperative complication. These complications increased the expenses by 78% and the length of hospital stay by 114%, both with a statistical significance. In our study, we were able to identify that patient with postoperative complications stayed in the hospital for more than 3 days in 60.71% of the cases. In cases with major complications (grades IIIa to IVb of the Clavien-Dindo classification), prolonged hospitalization was observed in 91.66% of the cases (P=0.018).

Although observational, non-interventional, retrospective studies have inherent limitations, the constraints of this study type were minimized through the standardization of data collection and the objective definition of the outcomes. Moreover, we emphasize that the data were collected from a single center with medical residency program in urology specialized in PCNL.

## Conclusion

This study showed that PCNL presents a low rate of complications, which are related to longer hospital stays, and most patients classified in the groups with greater complications tended to stay in the hospital for more than 3 days. There was evidence that calculus characteristics are directly related to the rate of residual stone fragments, especially in cases of grade III staghorn calculi. As for the other correlations between the patients' clinical characteristics and the grade of complication, no statistical significance was found. Establishing a classification system for complications, such as the modified Clavien-Dindo classification, can serve as the basis to improve the technique and result in fewer postoperative complications.

We recommend that cases of grade III staghorn calculi must be submitted to radiographic study to evaluate the presence of residual calculi, in order to complete the treatment.

This could lead to the emergence of new technological advances that can help reduce the rate of complications and prevent longer hospital stays, thereby resulting in lower expenses, as postoperative complications consume a considerable amount of healthcare resources.

## Acknowledgements

To the involved institution(s), the patients, and those that provided and cared for study patients. This work was supported by Reis LO: "National Council for Scientific and Technological Development"-CNPq, Research Productivity: 304747/2018-1.

## Disclosure of conflict of interest

None.

**Address correspondence to:** Dr. Leonardo O Reis, UroScience, University of Campinas and Pontifical Catholic University of Campinas, Av. John Boyd Dunlop-Jardim Ipaussurama, Campinas, SP 13034-685, Brazil. Tel: +55-19-3343-8600; E-mail: reisleo.l@gmail.com

## References

[1] Taylor E, Miller J, Chi T and Stoller ML. Complications associated with percutaneous nephrolithotomy. Transl Androl Urol 2012; 1: 223-8.

[2] Malkhasyan VA, Semenyakin IV, Ivanov VY, Sukhikh SO and Gadzhiev NK. Complications of percutaneous nephrolithotomy and their management. Urologiia 2018; 3: 147-53.

[3] Management of struvite or staghorn calculi-uptodate [Internet]. [cited 2020 Jan 15]. Available from: https://www.uptodate.com/contents/management-of-struvite-or-staghorn-calculi?search=management of struvite or staghorn&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1.

[4] Options in the management of renal and ureteral stones in adults - UpToDate [Internet].

[cited 2020 Jan 15]. Available from: https://www.uptodate.com/contents/options-in-the-management-of-renal-and-ureteral-stones-in-adults?search=options on the management of renal&source=search_result&selectedTitle=2~150&usagetype=default&display_rank.

[5] Michel MS, Trojan L and Rassweiler JJ. Complications in percutaneous nephrolithotomy. Eur Urol 2007; 51: 899-906.

[6] Fernández Alcalde ÁA, Ruiz Hernández M, Gómez dos Santos V, Sánchez Guerrero C, Diaz Pérez DE, Arias Fúnez F, Laso García I, Duque Ruiz G and Burgos Revilla FJ. Comparación entre nefrolitotomía percutánea y ureteroscopia flexible para el tratamiento de litiasis renales de entre 2 y 3 cm. Actas Urol Esp 2019; 43: 111-117.

[7] Azal Neto W, Reis LO and Pedro RN. Prediction of stone-free rates following extracorporeal shockwave lithotripsy in a contemporary cohort of patients with stone densities exceeding 1000 HU. Scand J Urol 2020; 54: 344-348.

[8] Azal Neto W, Morales E, Pachecco MJ, Pedro RN and Reis LO. Is extracorporeal shock wave lithotripsy (SWL) still suitable for >1.5 cm intrarenal stones? Data analysis of 1902 SWLs. Scand J Urol 2021; 55: 388-393.

[9] Krishna Reddy SV and Shaik AB. Outcome and complications of percutaneous nephrolithotomy as primary versus secondary procedure for renal calculi. Int Braz J Urol 2016; 42: 262-9.

[10] Felici EM, Diniz ALL, Souza TA, Favorito LA and Resende JAD Júnior. Can renal stone size and the use of the nephrolithometric system increase the efficacy of predicting the risk of failure of percutaneous nephrolithotripsy? Rev Col Bras Cir 2017; 44: 619-625.

[11] Zengin K, Sener NC, Bas O, Nalbant I and Alisir I. Comparison of pneumatic, ultrasonic and combination lithotripters in percutaneous nephrolithotripsy. Int Braz J Urol 2014; 40: 650-5.

[12] Violette PD and Denstedt JD. Standardizing the reporting of percutaneous nephrolithotomy complications. Indian J Urol 2014; 30: 84-91.

[13] Dindo D, Demartines N and Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004; 240: 205-13.

[14] Dindo D and Clavien PA. What is a surgical complication? World J Surg 2008; 32: 939-41.

[15] Kallidonis P, Panagopoulos V, Kyriazis I and Liatsikos E. Complications of percutaneous nephrolithotomy: classification, management, and prevention. Curr Opin Urol 2016; 26: 88-94.

[16] Tefekli A, Ali Karadag M, Tepeler K, Sari E, Berberoglu Y, Baykal M, Sarilar O and Muslumanoglu AY. Classification of percutaneous nephrolithotomy complications using the modified clavien grading system: looking for a standard. Eur Urol 2008; 53: 184-90.

[17] Khan NA, Quan H, Bugar JM, Lemaire JB, Brant R and Ghali WA. Association of postoperative complications with hospital costs and length of stay in a tertiary care center. J Gen Intern Med 2006; 21: 177-80.