

Hemorrhagic complications after mini-PCNL: retrospective analysis from a single high-volume center

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Research Article

Keywords: Endourology, Renal stones, Blood transfusion, Arterial embolization, Renal thickness

Posted Date: September 28th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10910191/v1>

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Additional Declarations: No competing interests reported.

Abstract

Purpose: Miniaturized percutaneous nephrolithotomy aims to reduce morbidity and hemorrhagic risk while maintaining efficacy in the treatment of large renal stones. The current study aimed to quantify hemorrhagic complications in patients undergoing mini-PCNL within a high-volume tertiary center.

Methods: We retrospectively reviewed all mini-PCNL procedures within a high-volume tertiary center, including those performed with a combined approach (mini-ECIRS) and simultaneous bilateral endoscopic surgery (SBES) between January 2018 and September 2025. All patients received a 7-day preoperative antibiotic regimen according to urine culture results. Renal puncture was performed under fluoroscopic guidance using the 0–90° technique, targeting a trans papillary access in all cases. Outcomes were hemorrhagic postoperative complications, hemoglobin (Hb) decline between pre-operative and postoperative tests, number of blood transfusions, embolization rate, and baseline and 3-months estimated glomerular filtration rate (eGFR). Specifically, complications were classified according to the Clavien–Dindo system.

Results: A total of 664 patients were analyzed and 79.81% (n=530) of all procedures were miniaturized (≤ 18 Fr). Overall, 20 patients (3.01%) exhibited hemorrhagic complications; of those 19 (2.86%) required blood transfusions while 11 (1.65%) required arterial embolization. Among patients who developed bleeding complications, the median stone volume was 5,7 (interquartile range [IQR] 4.0–9.3) mm³. The mean Hb decline was 3.3 (IQR 4.2–1.5) g/dL, with a median blood transfusion of 2 per patient (IQR 2–3). No significant changes in eGFR was observed at 3-month follow-up.

Conclusions: Mini-PCNL was associated with low rates of embolization and blood transfusion. It may represent a safe and effective procedure in complex cases.

Introduction

Hemorrhagic events remain one of the most relevant complications following percutaneous nephrolithotomy (PCNL), particularly in those procedures performed for a large stone burden. Reported bleeding rates ranges from 0 to 20%, with transfusion rates of up to 7% (1, 2). A recent systematic review completed by Harrison et al. showed that hemorrhagic complications were the third cause of death, followed by sepsis and myocardial infarction, in patients undergoing PCNL.(3) However, the advent of miniaturized techniques, such as mini-PCNL, has primarily aimed to reduce access-related morbidity while preserving satisfactory functional outcomes, as it was demonstrated by Zeng et al (4). To date, the rates of hemorrhagic complication within miniaturized techniques are still underestimated. In consequence, the current study aimed to evaluate hemorrhagic complications rate after mini-PNCL, using mainly 18Fr tract, relying on a large database from a referral Spanish high-volume center.

Materials and Methods

Surgical technique

Surgeries were performed by senior endourologists (O.A., and A.K.K.), a junior urologist (P.V.) and/or a urology resident (P.I.) and/or clinical fellow (L.F). Patients were places in the Galdakao-modified or Valdivia supine position, with silicon pads to elevate the patient's flank.

The standard technique starts with cystoscopy, inserting a 12 Fr nephroscope to place a guidewire into the ureter. A ureteral balloon catheter is subsequently introduced to perform retrograde pyelography in cases undergoing mini-PCNL. Most procedures were performed as endoscopic combined intrarenal surgery (ECIRS) using a single-use ureteroscope (Axis 7.5 Fr or Lithovue 9.5 Fr). In selected cases, simultaneous bilateral endoscopic surgery (SBES) was performed, defined as the combination of unilateral URS/RIRS and contralateral mini-PCNL or ECIRS carried out simultaneously.

Renal puncture was performed using a trans papillary approach under fluoroscopic guidance with the 0°–90° technique. (5) (6). In some cases, ultrasound and/or endoscopic vision were additionally used. An 18 G Chiba needle (Cook Medical, Bloomington, IN) was inserted into the collecting system, and a flexible 0.035" hydrophilic guidewire was advanced preferably into the ureter or alternatively into the upper pole calyx or another favorable calyx. (7, 8) The needle was removed and the skin and fascia were incised. Sequential dilation was performed using an 8 Fr fascial dilator followed by a 10/12 Fr dilator to allow placement of a second safety guidewire. Tract dilation was then achieved using either an Ultraxx™ 18 Fr balloon dilator (Cook Medical) inflated up to 20 ATM or a single-step Amplatz dilator. An 18 Fr Amplatz sheath was then inserted and nephroscopy was performed.

Stone fragmentation was preferentially carried out using a high-power Holmium-YAG laser. Flexible nephroscopy with a 16 Fr nephroscope was routinely performed to inspect other calyces and exclude stone fragment migration. A 3 Fr circle basket was used in most cases for stone extraction. A double-J ureteral stent was routinely placed at the end of the procedure. In selected cases (i.e. infective stones), an 8Fr-12Fr nephrostomy tube was left on open drainage. Finally, a 16 Fr urethral catheter was inserted. Standard postoperative care was provided in a dedicated urology ward, with nephrostomy tube removal on postoperative day 1 or day 2 according to clinical evolution.

Patients' characteristics

Overall 664 patients who underwent PCNL in a Spanish tertiary referral center were analyzed. Of those, we specifically focused on patients who developed hemorrhagic complications confirmed by contrast-enhanced computed tomography (CT). Moreover, the angiography was performed only in patients with active bleeding or vascular lesions at CT. Hemorrhagic complication was defined as hemoglobin (Hb) drop requiring transfusions or embolization.

Data on pre- and postoperative Hb levels, as well as blood transfusion and embolization rates, were recorded. Complications were classified according to the Clavien–Dindo system, as validated for PCNL by the CROES group (9). Preoperative renal parenchymal thickness was measured on CT scans in patients with

hemorrhagic complications.

Mean renal diameters were measured on axial images at the level of the renal hilum level. Superior cortical thickness was measured 2 cm below the upper pole, and inferior cortical thickness 2 cm above the lower pole of the kidney (10). Parenchymal thickness at the puncture site was assessed in axial non-contrast CT images using soft-tissue window (11).

Statistical analyses

Statistical analyses were performed using Jamovi 2.6.44 software. Descriptive statistics included medians and interquartile ranges (IQR) for continuously coded variables and frequencies and proportions for categorical variables. The percentages of patients who developed complications were calculated using row percentages.

Results

Overall population

A total of 664 patients were included: 380 were male (57.2%) and 284 were female (42.8%). According to the American Society of Anesthesiologists (ASA) classification, 95 patients (14.4%) were ASA 1, 418 (63.1%) ASA II, 147 (22.2%) ASA III, and 2 (0.3%) ASA IV. Staghorn stones were present in 126 cases (18.9%). Table 1 summarizes the intra-operative variables of the studied population. The median age was 62 years (range 41–74) and nine patients had an ASA score of III (45%). The median stone volume was 5,700 (IQR 4,000–9,350) mm³. Median preoperative renal parenchymal thickness was 16.2 IQR (13.3–19.33) mm when measured across all three calyces and 17.5 IQR (11.5–19.2) mm at the selected calyx for puncture.

Table 1
Percutaneous access variables

Variable		Global (n = 664)	Hemorrhagic complications (n = 20; 3%)
Mini PCNL (n, %)		32	7 (21.9)
Mini ECIRS (n, %)		575	13(2.3)
SBES (n, %)		77	2 (2.6)
Side	Right (n, %)	252	6 (2.4)
	Left(n, %)	338	10 (3)
	Bilateral(n, %)	70	4(5.7)
Number of PCNL accesses	Three (n, %)	3	0 (0)
	Two (n, %)	50	0 (0)
	One (n, %)	611	20(3.3)
Tract size	12 Fr (n%)	12	0 (0)
	14 Fr (n%)	48	1 (2.1)
	16 Fr (n%)	44	2 (4.5)
	18 Fr (n%)	530	15 (2.8)
	20 Fr (n%)	25	1 (4)
Multitract (n, %)		53	0 (0)
PCNL puncture location	Subcostal	653	18 (2.8)
	Supracostal	11	2(18.1)
Dilation method	Balloon(n, %)	559	18(3.2)
	Amplatz (n, %)	81	2 (2.5)
	Single-step (n, %)	31	0 (0)
	Alken(n%)	6	0 (0)
Renal access area	Lower calyx (n%)	549	15 (2.7)
	Middle calyx(n%)	106	4 (3.8)
	Superior calyx	33	1 (3)

Table 2
Complications.

Units of red blood cells transfused	Diagnostic of complication	Treatment
3	Bleeding 12 rib	Angioembolization
2	Hematoma/Urinary clot obstruction	SNF
1	Pseudoaneurysm	Angioembolization
2	Hematoma with active bleeding. Angiography was performed and the bleeding had stopped.	Medical treatment
5	Hematoma without active bleeding	Medical treatment
3	Hematoma + Pseudoaneurysm	Angioembolization
1	Pseudoaneurysm + arteriourinary fistula	Angioembolization
2	Hematoma without active bleeding	Medical treatment
3	Hematoma + pseudoaneurysm + active bleeding.	Angioembolization
2	Pseudoaneurysm + AV fistula	Angioembolization
2	Arteriourinary fistula	Angioembolization
0	Subcapsular hematoma with active arterial bleeding	Angioembolization
3	Hematoma	Puncture of infected collection
2	Hematoma without active bleeding	Medical treatment
3	Hematoma with signs of active bleeding	Angioembolization
2	No active bleeding is evident	Medical treatment
2	No hematoma or active bleeding is evident.	Medical treatment
1	Pseudoaneurysm + A-V fistula.	Angioembolization
2	Subcapsular renal hematoma without signs of active bleeding.	Medical treatment
1	Pseudo aneurysm + AV fistula	Angioembolization

Patients with hemorrhagic complications

Of 664 patients, 20 patients (3.0%) had a hemorrhagic complication, 19 (2.8%) requiring blood transfusion, 11 (1.6%) requiring arterial embolization, and one (0.1%) patient required a nephrostomy tube placement due to obstructive blood clots. The majority of patients who exhibited hemorrhagic complications were females (n = 11, 55%). According to comorbidities, nine were affected by arterial hypertension, six had type 2 diabetes mellitus, three were obese, two patients had a cystectomy with a urinary derivation, two had spinal cord injury and one patient had a solitary kidney. Specifically, five patients were on anticoagulation therapy.

Fourteen patients (70%) underwent mini-PCNL, six (25%) mini-ECIRS and one (5%) SBES. A single renal puncture was performed in all patients who exhibited hemorrhagic complications: 12 (60%) in the lower calyx, seven (35%) in the middle calyx, and one (5%) in the upper calyx. Of those, two were previously punctured by the radiologist before the surgery. The primary surgeon was a senior consultant in 15 cases (71.4%) and a resident in six cases (28.6%). At the end of the procedure, no nephrostomy tube was placed in 11 patients (55%). In the remaining cases, an 8 Fr nephrostomy tube without balloon was used in one patient, a 12 Fr tube with balloon in fourth patients, and a 12 Fr without balloon in one patient, 14 Fr tube with balloon in three patients.

Overall, among iatrogenic renal vascular lesions, pseudoaneurysm was observed in seven patients, followed by six perirenal hematomas with active bleeding, four perirenal hematomas without active bleeding, three arterio-venous fistula one arterial-urinary fistula and one subcostal arterial injury, in that order.

The median Hb decline was 3.3 (IQR 4.2–1.5) g/dL. Median Hb preoperative hemoglobin was 13.4 g/dL (IQR 12.6–13.9) and postoperative hemoglobin was 9.5 (IQR 8.4–11.1). The median time between surgery and onset of bleeding was 1 (IQR 1–2) days, and the median time between diagnosis of bleeding and embolization was 1 (IQR 1–3) days. The median of 2 blood transfusions per patient (IQR 2–3) was recorded. Only one patient received tranexamic acid. According to post-procedural morbidity for patients who were embolized: two patients reported flank pain and one developed arterial hypertension. Mean patient follow-up from diagnosis to last control visit was 23 (IQR11-33) months.

According to the Clavien-Dindo classification, hemorrhagic complications were graded CD II in six patients (30%), CD IIIa in 11 (55%), CD IIIb in one (5%), and, finally, CD IVb for those two (10%) who exhibited sepsis and cardiac arrest, respectively. No patient required repeat angioembolization.

No statistically significant change in eGFR was observed at 3-month follow-up, with pre- and post-operative values of 83 (IQR 58–100) and 73 (IQR 52–92) ml/min/m², respectively (p = 0.2). All patients were treated with a 7-day course of antibiotics, five had a nephrostomy tube before the surgery, and eight patients were pre-stented. Eleven patients (55%) were stone-free after treatment.

Discussion

Hemorrhagic complications remain one of the most relevant complications following percutaneous nephrolithotomy (PCNL). Specifically, they represent an inherent cause of death (3). While mini-PCNL ($\leq 20\text{Fr}$) reduces morbidity and bleeding risk while preserving an optimal SFR achievement, the hemorrhagic rates are still underestimated. We evaluated hemorrhagic complications in a high-volume tertiary center. We relied on a cohort of 664 patients with kidney stones treated with mini-PCNL, mini-ECIRS or SBES. To the best of our knowledge, it represents one of the largest cohorts on kidney stones patients treated with miniaturized approach in Europe. For instance, Meng et al. relied on a cohort of 396 patients underwent minimally-invasive PCNL. Conversely, a larger cohort of PCNL was retrieved in the study of Yang et al. and included 2,819 patients. However, those patients were treated in the prone position, making comparison with the current population difficult. Moreover, that study aimed to evaluate the role of 3D vessel reconstruction in predicting hemorrhagic complications after mini-PCNL. This differs from the aim of our study, which was to quantify the rate of hemorrhagic complications and to analyze the associated patient characteristics within a large mini-PCNL cohort. Thus, a direct comparison with those studies cannot be made.

Among the patients who exhibited hemorrhage, seven harbored arterial hypertension and six had type 2 diabetes mellitus. Both arterial hypertension and diabetes mellitus are recognised predictors for bleeding, being associated with 2.3-fold and 3.2-fold risk of bleeding, respectively (12). Additionally, five were also received anticoagulation therapy. This also may explain the rates of complications we retrieved in our cohort of patients. In the current study, the most common iatrogenic renal vascular lesion was pseudoaneurysm, observed in seven patients, followed by six perirenal hematomas with active bleeding, four perirenal hematomas without active bleeding, three arterio-venous fistula one arteries urinary fistula and one subcostal arterial injury. Furthermore, among these surgeries, seven patients underwent mini-PCNL, 13 ECIRS, and two SBES. Specifically, single access, with the placement of 18Fr access sheath, was predominantly performed.

Our rate of hemorrhagic complications was 3% while the transfusion rate was 2% and the embolization rate was 1.6%. These rates are consistent with previous studies that reported arteriographic embolization rates ranging from 0.6% to 4.4% and transfusion rates from 1% to 11% for severe bleeding after PCNL (12) + (14). In our practice, an anatomical transpapillary puncture using a 0–90° fluoroscopic technique is systematically performed. Although Kallidonis et al reported comparable safety between transpapillary and non-transpapillary punctures, other authors have suggested that this approach may reduce the risk of major bleeding (13). In addition, the dilation method appears to be clinically relevant. The meta-analysis by Peng et al. (14) demonstrated that balloon dilation is associated with a significantly smaller postoperative hemoglobin decrease and shorter access time compared with Amplatz dilation, while maintaining similar transfusion and overall complication rates. Because balloon dilation was used in most of our procedures, the combination of transpapillary puncture and balloon dilation up to 18 Fr may partially explain the low rate of hemorrhagic complications observed in our series. Similarly, mean preoperative renal parenchymal thickness was 16.2 IQR (13.3–19.33) mm when measured across all three calyces and 17.5 IQR (11.5–19.2) mm at the selected calyx for puncture. Recent literature indicates that reduced cortical thickness ($\leq 17\text{mm}$) is a predictive factor for postoperative bleeding, likely due to diminished buffering capacity and closer proximity of major vessels (13) (14) (16). Interestingly, the mean hemoglobin decrease observed in our study 3.3 g/dL falls within the range reported for PCNL in the literature, which varies from 2.23 g/dl (17) to 5.3 g/dL (18). In our cohort, the mean time to onset of bleeding after mini-PCNL was 1 day. One possible explanation for the earlier detection in our series is the routine use of contrast-enhanced CT when the postoperative course deviates from the expected evolution, particularly in the presence of haematuria or other clinical signs suggestive of bleeding. Importantly, no deterioration in renal function at 3-month follow-up, even among patients who required embolization. This observation is consistent with previous studies showing that super selective embolization generally preserves renal parenchyma and does not result in clinically significant renal function impairment, except in patients with solitary kidneys or advanced pre-existing renal disease (18) (16). In our cohort, the stability of chronic kidney disease stage further supports the functional safety of this approach. The low incidence of severe hemorrhagic complications observed in our study may support the concept that tract miniaturization plays an important role in reducing clinically significant bleeding. However, single-center design and the low absolute number of severe hemorrhagic events, precluded multivariable analysis and limit causal inference.

This study represents one of the largest single-center experiences evaluating hemorrhagic complications after mini-PCNL in a high-volume tertiary referral center. The use of a standardized surgical technique, including systematic trans papillary access and predominantly balloon dilation, strengthens internal validity, while the inclusion of complex procedures such as mini-ECIRS and SBES enhances real-world applicability. Routine contrast-enhanced CT for suspected bleeding enabled precise vascular lesion characterization and optimized management, with preservation of renal function at mid-term follow-up. However, single-center design and the low absolute number of severe hemorrhagic events, precluded multivariable analysis and limit causal inference. Thus, several larger comparative studies are needed to confute or prove the current findings.

Conclusions

In our study cohort, hemorrhagic complications after mini-PCNL are uncommon (3%), with low transfusion (2%) and embolization (1.6%) rates, consistent with current literature.

Standardized techniques, such as transpapillary puncture and balloon dilation up to 18Fr, may contribute to reducing bleeding risk without compromising functional outcomes.

Despite these favorable findings, larger multicenter studies are needed to validate these results and better define risk factors.

Declarations

a) Competing Interests and Funding

This study received no specific funding from any public, commercial, or not-for-profit funding agency.

b) Conflict of interest statement

O. Angerri declares conflicts of interest: Cook medical Consultant & speaker, Boston scientific Consultant & speaker, Ambu Consultant, Devicare Speaker, Storz Consultant. All other authors declare that they have no conflicts of interest relevant to this work.

c) Data availability statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

d) Consent to participate statement

Not applicable. Due to the retrospective nature of the study and the use of anonymized data, individual consent to participate was not required.

e) Consent to publish statement

Not applicable. No individual patient-identifiable data are included in this manuscript; therefore, consent to publish was not required.

f) Ethical statement

Ethical approval

was waived by the Institutional Ethics Committee due to the retrospective nature of the study and the use of previously collected, anonymized data. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Author Contribution

Authors' contribution: Lucio Fila and Francesco Di Bello: methodology, formal analysis, writing original draft Paolo Verri: data curation, review & editing, Alejandra Bravo-Balado: data curation, review & editing, Andres Kanashiro: data curation, review & editing Paula Izquierdo: data curation, review & editing Oriol Angerri: conceptualization, methodology, investigation, supervision.

Acknowledgement

To our librarian Ricard, Pallejero Augué who supplies us with everything required for our tasks.

References

1. Seitz C, Desai M, Häcker A, Hakenberg OW, Liatsikos E, Nagele U et al (2012) Incidence, Prevention, and Management of Complications Following Percutaneous Nephrolitholapaxy. *Eur Urol* 61(1):146–158. 10.1016/j.eururo.2011.09.016
2. Escobar Monroy R, Proietti S, De Leonardis F, Gisone S, Scalia R, Mongelli L et al (2025) Complications Percutaneous Nephrolithotomy Complications 2(1):5. 10.3390/complications2010005
3. Harrison NL, Dassanayake SN, Heppenstall-Harris GZ, Skolarikos A, Chawla A, Liatsikos E et al (2026) Mortality from Percutaneous Nephrolithotomy: A Systematic Review from European Association of Urology Endourology. *Eur Urol Focus* S2405456926000052. 10.1016/j.euf.2026.01.004
4. Zeng G, Cai C, Duan X, Xu X, Mao H, Li X et al (2021) Mini Percutaneous Nephrolithotomy Is a Noninferior Modality to Standard Percutaneous Nephrolithotomy for the Management of 20–40 mm Renal Calculi: A Multicenter Randomized Controlled Trial. *Eur Urol* 79(1):114–121. 10.1016/j.eururo.2020.09.026
5. Manzo BO, Gómez F, Figueroa A, Sánchez HM, Leal M, Emiliani E et al (2020) A New Simplified Biplanar (0–90°) Fluoroscopic Puncture Technique for Percutaneous Nephrolithotomy. Reducing Fluoroscopy Without Ultrasound. Initial Experience Outcomes *Urol* 140:165–170. 10.1016/j.urology.2020.03.002
6. Escovar Cirugía Renal Percut_anea: la puncion... Google Académico [Internet]. [cited 2026 Apr 19]. Available from: https://scholar.google.com/scholar_lookup?title=Cirug%C3%ADa%20Renal%20Percut%C3%A1nea%20la%20punci%C3%B3n%20en%2090%20grados.%20Una%20técnica%20fácil%2C%20eficient73
7. Gökce Mİ, Babayiğit M, Kubilay E, Aydoğ E, Oktar A, Akpınar Ç et al (2021) Is it necessary to have a guidewire down through the ureter during mini percutaneous nephrolithotomy? Single-centre experience with 1052 cases. *Int J Clin Pract* 75(9). 10.1111/ijcp.14430
8. Sadiq AS, Atallah W, Khusid J, Gupta M (2021) The Surgical Technique of Mini Percutaneous Nephrolithotomy. *J Endourol.* ;35(S2):S-68-S-74. 10.1089/end.2020.1080
9. De La Rosette JJMCH, Opondo D, Daels FPJ, Giusti G, Serrano Á, Kandasami SV et al (2012) Categorisation of Complications and Validation of the Clavien Score for Percutaneous Nephrolithotomy. *Eur Urol* 62(2):246–255. 10.1016/j.eururo.2012.03.055
10. Mounier-Vehier C, Lions C, Devos P, Jaboureck O, Willoteaux S, Carre A et al (2002) Cortical thickness: An early morphological marker of atherosclerotic renal disease. *Kidney Int* 61(2):591–598. 10.1046/j.1523-1755.2002.00167.x

11. Karalar M, Tuzel E, Keles I, Okur N, Sarici H, Ates M (2016) Effects of Parenchymal Thickness and Stone Density Values on Percutaneous Nephrolithotomy Outcomes. *Med Sci Monit* 22:4363–4368. 10.12659/MSM.898212
12. Hu Y, Wang X, Chen Y, Zhong Y, Zhu F, Yuan Y et al (2025) Risk factors for severe bleeding associated with percutaneous nephrolithotomy: A meta-analysis. *Med (Baltim)* 104(31):e43606. 10.1097/MD.00000000000043606
13. Alabat Roca A, Torrecilla Ortíz C, Cuadrado Campaña JM, Colom Freixas S, Fernández-Concha Schwalb J, Beato García S et al (2021) Hemorrhagic complications after percutaneous nephrolithotomy: The importance of an early endovascular management. *Actas Urol Esp Engl Ed* 45(10):635–641. 10.1016/j.acuroe.2021.10.002
14. Seitz C, Desai M, Häcker A, Hakenberg OW, Liatsikos E, Nagele U et al (2012) Incidence, Prevention, and Management of Complications Following Percutaneous Nephrolitholapaxy. *Eur Urol* 61(1):146–158. 10.1016/j.eururo.2011.09.016
15. Sun H, Chen Z (2025) Integration of minimally invasive techniques and interventional therapy: application of percutaneous nephrolithotomy in patients with upper urinary tract stones and an analysis of risk factors for postoperative bleeding. *Front Med* 12:1556224. 10.3389/fmed.2025.1556224
16. Martin X, Murat FJ, Feitosa LC, Rouvière O, Lyonnet D, Gelet A et al (2000) Severe bleeding after nephrolithotomy: results of hyperselective embolization. *Eur Urol* 37(2):136–139 doi:10.1159/000020129 PubMed PMID: 10705189
17. Meng X, Bao J, Mi Q, Fang S (2019) The Analysis of Risk Factors for Hemorrhage Associated with Minimally Invasive Percutaneous Nephrolithotomy. *BioMed Res Int* 2019:1–6. 10.1155/2019/8619460
18. El Tayeb MM, Knoedler JJ, Krambeck AE, Paonessa JE, Mellon MJ, Lingeman JE (2015) Vascular Complications After Percutaneous Nephrolithotomy: 10 Years of Experience. *Urology* 85(4):777–781. 10.1016/j.urology.2014.12.044