Original Article

Renal calyx access does not affect intraoperative blood loss in percutaneous nephrolithotomy: a single-center retrospective study

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Abstract

Objective: Percutaneous nephrolithotomy (PCNL) is one of the most effective ways of dealing with large renal calculi but also comes with a risk of intraoperative blood loss. Previous evidence is contradictory as regards the difference in blood loss between different renal calyx access. We conducted this study to compare intraoperative blood loss between different renal access calyx.

Materials and Methods: We conducted a retrospective study analyzing 132 cases of single access PCNL, dividing them into an upper pole group (n = 93) and a non-upper pole group (n = 39). Intraoperative blood loss was calculated from pre-and post-operative hematocrit level, gender, body surface area, and amount of blood transfusion. Blood loss was compared between the two groups using univariable and multivariable analysis.

Results: Overall blood loss was 500 ml (IQR 200-814 ml) with a median blood loss of 461 ml (IQR 158-738 ml) in the upper pole group and 650 ml (IQR 332-1233 ml) in non-upper pole group. Median hematocrit change was 2.9% and 3.9% in the upper and non-upper pole groups, respectively. The blood transfusion rate was 4.5% in the upper pole group and 8.3% in the non-upper pole group. The multivariable analysis did not demonstrate any statistically significant difference in average blood loss, hematocrit change or blood transfusion rate.

Conclusions: Our study did not find any significant difference in intraoperative blood loss between different renal access routes in PCNL.

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Introduction

Percutaneous nephrolithotomy (PCNL) is one of the most common urologic procedures and is the cornerstone for the treatment of large renal calculi. PCNL has an advantage over other renal calculi treatments, including extracorporeal lithotripsy (ESWL) and retrograde intrarenal surgery (RIRS), owing to its close and direct contact with the calculi and the large size of the access tract. These factors allow for a more comprehensive selection of lithotripters and more aggressive irrigation, which results in a better stone clearance. Nevertheless, its superiority comes with a price. Large renal parenchymal damage, in conjunction with the highly vascularized nature of the kidney tissue, can pose a much higher risk of intraoperative and post-operative blood loss than other alternatives.[1]

A study using fluoroscope-guided renal access with 3D polyester corrosion endocast of the collecting system, arteries, and veins in cadavers revealed that renal access through the upper infundibulum had a much higher risk of arterial injury, mostly to the interlobar artery than its middle or lower counterpart.[2] However, a more recent retrospective clinical study reported a higher risk of severe blood loss in lower pole renal access PCNL compared to middle and upper pole.[3] Another retrospective study also reported a higher transfusion rate in association with renal access in the lower pole.[4,5] These authors provided hypotheses explaining their findings which were either that the lower pole kidney may be richer in arterioles or that the difficulty in the placement of a guidewire in the lower pole may require more tract manipulation. Another case series reported no significant difference in blood transfusion between different routes of renal access.[6]

A conflict of evidence from basic science and clinical research have led us to conduct this study to determine if there is a difference in intraoperative blood loss between upper pole and non-upper pole renal access sites.

Materials and Methods

Patients and population

This study was initiated after approval from the institutional review board of our institution (Protocol number MTU-EC-SU-0-127/62). A retrospective review was performed on all patients undergoing PCNL between 2012-2019. Data were collected from electronic medical records, including laboratory results, and from radiology information systems.

Patients aged more than 18 years who had undergone single tract standard PCNL with telescopic dilatation were included in this study. Exclusion criteria were a tendency of bleeding, abnormal renal anatomy, performance of the surgery in a non-prone position, and cases with insufficient data regarding hematocrit and renal access site. Cases with an unintentional infundibular injury during operation that resulted in early termination of the procedure were also excluded to prevent outliers. Abnormal renal anatomy included a horseshoe kidney, transplanted kidney, and any other anatomical abnormalities that could affect the difficulty of renal access.

Baseline patient data collected were age, height, body weight, American Association of Anesthesiology (ASA) classification, and the presence of hypertension and diabetes. Stone burden was collected as maximum stone diameter and estimated stone surface area obtained from anteroposterior plain radiograph or coronal view of computerized tomography, with or without intravenous contrast media injection. Stone surface area was calculated using a formula recommended by the European Association of Urology.[7] Operative data collected was presence of hydronephrosis of renal access tract, renal access site, size of access tract, preoperative hematocrit, post-operative hematocrit, and operative time. The presence of hydronephrosis was defined in accordance with the SFU classification.[8] Outcome data included stone clearance, blood transfusion between pre/post-operative hematocrit and post-operative complications. The Clavien-Dindo classification system for PCNL was used to grade post-operative complications.[9]

Estimated intraoperative blood loss was calculated using a formula described in a study by Syahputra et al., 2016, which uses gender, body surface area, pre-and post-operative hematocrit level, and blood transfusion during that period.[10]

Sample size (N) was calculated through a pilot study of 10 cases of upper pole access PCNL with an average intraoperative blood loss of 733±160 ml. As previous data is contradictory and there may not be any difference in blood loss, an equivalent trial may be ideal but would require a much larger sample size than available at our institution. We, therefore, computed sample size as a non-inferiority trial with a hypothesis that blood loss in the non-upper pole access group would exceed no more than 15% of that in the upper pole access group. Sample size was then calculated with STATA version 15.1 (StataCorp LLC, Texas, United States) using a two-sample means test, a $p < 0.05$ and power of 0.8. At our institution, upper pole access is performed approximately three times more frequently than non-upper pole access therefore we calculated a sample size based on this ratio, which resulted in a sample size of 92 cases in the upper pole access group (group 1) and 31 patients in the non-upper pole access group (group 2).

Surgical technique

Prophylactic antibiotics were given to all patients in accordance with their previous urine culture and sensitivity. All procedures were performed by two experienced urologists under general anesthesia. A rigid cystoscope was used to insert a ureteral catheter into the renal pelvis of the target kidney. The patient was then turned into a prone position. Contrast media was then injected into the renal pelvis, and localization was achieved using a fluoroscope. After localization, the access tract was dilated using metallic telescopic dilators, an Amplatz sheath of 30F was then inserted into the renal pelvis. Lithotripsy was achieved by ShockPulse (Olympus corp., Tokyo, Japan), Swiss LithoClast (Boston Scientific, Mass., United States), or holmium laser. Stone fragments were extracted by stone forceps, stone baskets, and fluid irrigation. Operative time was recorded from the first needle puncture to skin closure.

Statistical analysis

Statistical analysis was performed using STATA version 15.1 (StataCorp LLC, Texas, United States). Categorical data are presented as numbers and percentage and analyzed using the Fisher-exact test. Continuous data are presented as mean (SD) (for data with a normal distribution) or median (IQR) (for data with an abnormal distribution) and analyzed with a t-test or Mann-Whitney U test. After exploring our data, the primary outcomes (total blood loss and Hct change) were non-parametric; thus, we decided to use quantile regression analysis for total blood loss, post-operative hematocrit change, and risk of blood transfusion using risk regression analysis. Factors included in the multivariable analysis were factors known to affect blood loss, including age, sex, BMI, hypertension, diabetes, hydronephrosis, stone surface area, operative time, operation side, and ASA Classification.[11-15] A $p < 0.05$ was considered statistically significant.

Results

Data collection from March 16, 2012, to June 31, 2019, yielded 179 PCNL cases with single tract renal access. Forty operations were excluded due to insufficient data, and seven others were excluded in accordance with the exclusion criteria, resulting in a total of 132 operations for inclusion in the analysis. Ninety-three operations were classified as upper pole renal access (group 1) and 39 as non-upper pole (group 2). The apparent difference in the number of cases in groups 1 and 2 was most likely due to a high prevalence of staghorn stones and those with large stone burdens at our institution, which are more likely to be managed with upper pole access.

Overall baseline patient characteristics were similar between the two groups (Table 1). The average ages were 55 and 52 years in groups 1 and 2, respectively. With regard to the operative data, the median stone surface area was 710 mm^2 and 532 mm^2 in groups 1 and 2, respectively, with an average stone diameter of 33 mm in both groups. Operative time was an average of 87 minutes in group 1 and 81 minutes in the other. Hydronephrosis at the access site was present in 70% and 71% in groups 1 and 2. None of these parameters showed any statistical difference. There was also no difference in the side, operative time, preoperative hydronephrosis of renal calyx access, or preoperative hematocrit between the two groups.

The median hematocrit drop was 2.9% in group 1 and 3.9% in group 2 ($p = 0.035$). Estimated intraoperative blood losses were 461 ml and 650 ml in group 1 and group 2, respectively ($p = 0.005$). Transfusion rate between the two groups which were 4.5% in group 1 and 8.3% in group 2 ($p = 0.421$) (Table 2).

Further multivariable analysis between various factors and hematocrit change, intraoperative blood loss, and risk of blood transfusion revealed no statistically significant difference between the two groups (Table 3).

Table 1. Baseline patient characteristics, stone characteristics and operative data

	Upper pole (group 1) (n = 93)	Non-upper pole (group 2) (n = 39)	P-value
Patient characteristics			
Age, years, mean (SD)	55 (13)	52 (12)	0.321
Sex, n (%)			0.564
Male	54 (58)	25 (64)	
Female	39 (42)	14 (36)	
BMI, kg/m^2, mean (SD)	25.66 (4.8)	26.37 (4.37)	0.428
ASA Classification, n (%)			0.655
I	23 (25)	8 (21)	
II	50 (54)	22 (56)	
III	20 (21)	9 (23)	
Hypertension, n (%)			0.184
Yes	53 (57)	17 (44)	
No	40 (43)	22 (56)	
Diabetes, n (%)			0.054
Yes	14 (15)	12 (31)	
No	79 (85)	27 (69)	
Stone characteristics			
Maximum stone diameter, mm, mean (SD)	33 (13)	33 (18)	0.888
Cumulative stone surface area, mm^2, median (IQR)	710 (338-1140)	532 (276 -1067)	0.440
Operative characteristics			
Side, n (%)			0.568
Right	49 (53)	23 (59)	
Left	44 (47)	16 (41)	
Operative time, min, mean (SD)	87 (37)	81 (37)	0.346
Hydronephrosis of access site, n (%)	63 (70)	24 (71)	0.999
Preoperative hematocrit, % (SD)	38 (5.6)	39 (6.0)	0.399

SD = standard deviation, BMI = body mass index, ASA = American Society of Anesthesiology, IQR = interquartile range

Table 2. Operative outcomes

	Upper pole (n = 93)	Non-upper pole (n = 39)	P-value
Hematocrit change, %, median (IQR)	2.9 (0.6-5.4)	3.9(1.6-7.4)	0.035
Total blood loss, ml, median (IQR)	461 (158-738)	650 (332-1233)	0.005
Transfusion, n (%)			0.421
Yes	4 (4.5)	3 (8.3)	
No	89 (95.5)	36 (91.7)	

IQR = interquartile range

Table 3. Regression analyses comparing non-upper pole access to upper pole access

	Difference	95% CI	P-value
Median Hematocrit change difference[a], %	1.28	-0.63 - 3.2	0.187
Total blood loss difference[a], ml	191	-47 - 429	0.115
Relative Risk Ratio of Blood transfusion[b]	1.5	0.64 - 3.52	0.345

[a]Quantile regression analysis adjusted with age, sex, BMI, presence of hypertension, diabetes, hydronephrosis, stone surface area, operative time, operation side, and ASA classification

[b]Binary regression analysis adjusted with age, sex, BMI, presence of hypertension, diabetes, hydronephrosis, stone surface area, operative time, operation side, and ASA classification

Table 4. Post-operative complications; Modified Clavien Classification

		Upper pole	Non-upper pole	Total	P-value
Grade	n (%)				0.173
	0	18 (20)	14 (37)	32 (25)	
	1 (Fever)	37 (40)	13 (34)	50 (38)	
	2 (Transfusion, IV antibiotics)	23 (25)	10 (26)	33 (25)	
	3a (Intercostal drainage, ureteral stenting, embolization)	12 (13)	1 (3)	13 (10)	
	3b (VATS)	1 (1)	0 (0)	1 (1)	
	4a	1 (1)	0 (0)	1 (1)	

Complications, as classified by the modified Clavien system, were found to be similar between the two groups. Fifty patients were found to have a postoperative fever without the need for any interventions, 37 from group 1 and 13 from group 2 (Table 4). With regard to grade 2 complications, 25% of group 1 and 26% of group 2 required transfusion or a change in intravenous antibiotics. Thirteen percent of group 1 and three percent of group 2 were classified as grade 3a complications. Interventions required in this group included intercostal drainage, ureteral stenting, and angioembolization. Thoracic complications were observed in 7 cases in group 1 and 1 case in group 2, all of which required intercostal drainage. No colonic injury occurred in this study. One patient from group 1 was classified as grade 3b complications due to the requirement of video-assisted thoracoscopy (VATS) from empyema thoracis. Another patient from group 1 had postoperative sepsis requiring monitoring in intensive care, which was classified as grade IVa. No patients in group 2 presented with grade IIIb or IV complications.

Discussion

Previous studies regarding intraoperative blood loss in percutaneous nephrolithotomy all shared a common problem in quantifying the amount of blood loss due to the nature of any urologic procedure with continuous fluid irrigation, which renders a conventional methods of gauze counting and intraoperative suction measurement virtually useless. Many studies have shifted to measuring the difference between pre/postoperative hematocrit or hemoglobin levels which could be easily confounded by intraoperative blood transfusion.[5,16,17] Others have shifted entirely to recording blood transfusion or angioembolization rate[3,4,18], which would usually only detect a large amount of blood loss, and a clinical decision for transfusion or embolisation could be affected by various confounders. Hurle et al. proposed a more sophisticated method of estimating blood loss that takes body surface area, sex, and amount of blood transfusion into account[19], which was later adopted by Syahputra et al. in 2016.[10] Therefore, we adopted this method of blood loss estimation, believing that this method could give a more accurate estimate of blood loss.

The upper pole renal access tract has advantage over other poles as it allows the rigid nephroscope to access other calyces, the renal pelvis, and the proximal ureter in a straight line, which results in better access for complex stones than either middle or lower pole access tracts.[20] Upper pole access also provides better access for staghorn stones and those with associated ureteropelvic junction obstruction.[21] Nevertheless, the upper pole access tract also comes with a higher risk of pleural injury, with potential manifestation into a more serious complication such as empyema thoracis. While posing a relatively low risk of pleural complication, lower pole access has a slightly higher risk of colon injury. The selection of renal access tract is dependent on numerous factors, including stone burden, stone geometry, stone location, adjacent organ location, and surgeon preference, thus, not every access tract is suitable for every patient. However, the difference in blood loss between each access tract, if any, may allow the surgeon to be better prepared for the operation.

The total blood loss in non-upper pole access was statistically significantly slightly higher than in upper pole access. A median hematocrit change of 2.9% and 3.9% in the upper and non-upper pole groups, respectively, were consistent with previous reports.[12,22] Hematocrit change was also significantly higher in the non-upper pole group. However, the amount of blood loss could be influenced by various factors. The adjusted analysis with factors previously known to affect blood loss revealed no significant difference between the two groups in terms of blood loss, hematocrit change and risk of blood transfusion. These results helped confirm previous data published by Singh et al. in a prospective study of 82 patients, which reported no significant difference in hemoglobin loss between groups.[21]

Previous existing data from a cross-sectional study in 131 cases of PCNL demonstrated no difference in transfusion rate between different renal calyx access and an overall transfusion rate of 18%.[23] Other studies also demonstrated similar results with an overall transfusion rate at 9.3-9.4%.[6,24] Our results confirmed these data, showing no statistically significant difference between upper and non-upper calyx renal access.

This study reports overall complications of 75 %, but 63% were only minor complications, similar findings to a previous large study.[25] Both groups showed no statistically significant difference in complication rates for overall complications. However, thoracic complications were higher in group 1 (7 in group 1 vs. 1 in group 2). This observation is consistent with previous data, which reported an overall thoracic complication rate of between 3-16%[26,27] with higher frequency in the upper pole renal access group.[28]

The main points of the study are:

- Intraoperative blood loss is one of the major concerns of most surgeons when performing PCNL, but data regarding blood loss between different renal calyx access is scarce.
- We conducted a retrospective analysis using a previously verified reliable intraoperative blood loss calculation, and the data did not demonstrate a correlation between renal calyx access and intraoperative blood loss.
- The incidence of complications was similar between different renal calyx access.

A further prospective trial is still needed to confirm or refute the lack of correlation and be used in clinical practice.

This study harbors some limitations that might affect the validity of the results. In a large number of cases data was incomplete, 40 cases from a total of 179 cases, a proportion which could affect the reliability of the results due to small sample size. This study also excluded cases with other methods of tract dilatation than metallic telescopic dilators, such as fascial dilator and balloon dilator, which might also affect the amount of intraoperative blood loss.[11]

Conclusion

There was no demonstrable significant difference in the amount of intraoperative blood loss, hematocrit change, and blood transfusion between different renal access routes in this study. The frequency of complications was also similar between different renal access routes.

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