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First Prize

# Factors Affecting Blood Loss During Percutaneous Nephrolithotomy: Prospective Study

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## ABSTRACT

***Background and Purpose*: Bleeding is a major concern during percutaneous nephrolithotomy (PCNL), especially with the use of multiple tracts. This prospective study aimed to identify factors affecting blood loss during PCNL.**

***Patients and Methods*: Data were collected prospectively from 236 patients undergoing 301 PCNL procedures at our institute since June 2002. Blood loss was estimated by the postoperative drop in hemoglobin factored by the quantity of any blood transfusion. Various patient-related and intraoperative factors were assessed for association with total blood loss or blood transfusion requirement using stepwise multivariate regression analysis.**

***Results*: The average hemoglobin drop was 1.68 ± 1.23 g/dL. Stepwise multivariate regression analysis showed that the occurrence of operative complications ($P < 0.0001$), mature nephrostomy tract ($P < 0.0001$), operative time ($P < 0.0001$), method of access guidance (fluoroscopy *v* ultrasound) ($P = 0.0001$), method of tract dilatation ($P = 0.0001$), multiple (≥2) tracts ($P = 0.003$), size of the tract ($P = 0.001$), renal parenchymal thickness ($P = 0.05$), and diabetes ($P = 0.05$) were significant predictors of blood loss. The overall blood transfusion rate for all patients was 7.9%. Preoperative hemoglobin, multiple tracts, stone size, and total blood loss were significant in predicting perioperative blood transfusion requirement. Factors such as age, hypertension, renal insufficiency, urinary infection, the degree of hydronephrosis, stone bulk, and the function of the ipsilateral renal unit did not have any effect on the blood loss. Technical factors such as the operating surgeon and the calix of entry also did not affect the blood loss.**

***Conclusions*: Diabetes, multiple-tract procedures, prolonged operative time, and the occurrence of intraoperative complications are associated with significantly increased blood loss. Atrophic parenchyma and past ipsilateral intervention are associated with reduced blood loss. On the basis of this evidence, maneuvers that may reduce blood loss and transfusion rate include ultrasound-guided access, use of Amplatz or balloon dilatation systems, reducing the operative time, and staging the procedure in cases of a large stone burden or intraoperative complications. Reducing the tract size in pediatric cases, nonhydronephrotic systems and those with a narrow infundibulum, and secondary tracts in a multiple-tract procedure may also reduce blood loss during PCNL.**

## INTRODUCTION

PERCUTANEOUS NEPHROLITHOTOMY (PCNL) is an integral component of the management of large-volume renal calculous disease. It has the possible advantages of better stone clearance rates, cost-effectiveness, and early convalescence compared with other modalities such as SWL and open stone surgery.[1] Indications for PCNL include large stone bulk (>3 cm), staghorn (complete and partial) calculi, complex or multiple calculi, renal insufficiency, recurrent stones, and failed alternative modalities.

A key requisite to stone clearance is establishing optimal access to the renal collecting system. A high-flow arteriovenous network constituting 20% of the total cardiac output closely sur-

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TABLE 1. DEMOGRAPHIC AND CLINICAL DETAILS

| | |
|---|---|
| No. of patients | 301 |
| Average age (years) | 43.7 ± 15.4 (range 1–95 yrs) |
| M/F | 227/74 |
| Body mass index | 23.05 ± 4.55 |
| Hypertension | 70 (23.2%) |
| Diabetes | 31 (10.3%) |
| Mean serum creatinine (mg/dL) | 1.17 ± 0.5 (range 0.4–4) |
| Urinary infection present on culture | 49 (16.3%) |
| Average stone bulk ($mm^2$) | 538.6 ± 569.3 (range 96–4125) |
| Stone type | |
| Pelvic | 46 |
| Caliceal | 36 |
| Multiple or complex | 105 |
| Ureteral | 31 |
| Partial staghorn | 49 |
| Complete staghorn | 34 |
| Operating surgeon[a] | |
| Category A | 155 |
| Category B | 99 |
| Category C | 47 |

[a]See text for definitions.

rounds the collecting system. Significant among these are the segmental and the interlobar vessels. Access to the pelvicaliceal system and intrarenal manipulations may traumatize these vessels, resulting in significant bleeding.[2–4] Bleeding is a significant morbidity during PCNL, with reports quoting an average hemoglobin drop ranging from 2.1 to 3.3 g/dL.[4–6] As a result, 1% to 11% of patients overall, and 2% to 53% of those with staghorn calculi, require blood transfusions.[1–10] While most bleeding associated with PCNL can be managed conservatively, approximately 0.8% of patients require angioembolization to control intractable bleeding.

Complex and staghorn calculi with multiple caliceal involvement often require multiple tracts to achieve better clearance and reduce the dependence on secondary procedures such as SWL. However, multiple-tract procedures have been associated with increased bleeding and transfusion rates.[4,11]

This prospective study was planned with the aim of studying various patient- and procedure-related factors with respect to bleeding. On the basis of our findings, we propose certain procedural modifications in an attempt to reduce bleeding and the transfusion rate.

## PATIENTS AND METHODS

Since June 2002, data from 301 PCNL procedures in 236 patients were prospectively analyzed; 65 patients underwent bilateral or multiple procedures. The average age was 43.7 ± 15.4 years (range 1–95 years). Detailed demographic and clinical data are described in Table 1. Clinical assessment included the age, sex, body mass index, symptomatology, evidence of any previous intervention for stone disease, and the presence of comorbidities such as hypertension and diabetes. Laboratory data included preoperative routine complete blood count, serum creatinine (normal 0.5–1.5 mg/dL), platelet count, bleeding and coagulation profile, and urine culture. A plain (KUB) film and renal ultrasound scan were done in all patients. Intravenous

TABLE 2. FACTORS ANALYZED

| *Patient related* | *Procedure related* |
|---|---|
| Age | Operating surgeon |
| Hypertension | Prior PCN |
| Diabetes | Method of puncture (Ultrasound/fluoroscopy) |
| Urinary infection | Calix of puncture |
| Serum creatinine | Number of attempts to successful puncture |
| Past ipsilateral intervention (open surgery, PCNL, or SWL) | Urine from puncture needle (clear or hemorrhagic) |
| Function of affected kidney | Method of tract dilatation |
| Parenchymal thickness | Size of the tract |
| Degree of hydronephrosis | Number of tracts |
| Stone surface area | Intraoperative complications |
| | Operative time |

TABLE 3. STEPWISE MULTIVARIATE REGRESSION ANALYSIS WITH HEMOGLOBIN LOSS AS RESPONSE VARIABLE

| *Factor* | *Subcategorization* | P *value*[a] |
|---|---|---|
| Age | Numerical[b] | 0.06 |
| Hypertension | Normotensive (0), hypertensive (1) | 0.66 |
| Diabetes | Nondiabetic (0), diabetic (1) | 0.05 |
| Urinary infection | Absent (0), present (1) | 0.21 |
| Serum creatinine (mg/dL) | <1.6 (0), >1.5 (1) | 0.74 |
| Past stone intervention | Absent (0), present (1) | 0.02 (neg) |
| Function of affected kidney | Normal (0), delayed/suppressed (1) | 0.49 |
| Parenchymal thickness (mm) | Numerical | 0.05 |
| Degree of hydronephrosis | Nil or mild (0), moderate or gross (1) | 0.71 |
| Stone surface area ($mm^2$) | Numerical | 0.03 |
| Operating surgeon | A (0), B (1), C (2) | 0.96 |
| Prior PCN | Yes (0), no (1) | <0.0001 |
| Method of access | Ultrasound (0), fluoroscopy (1) | 0.0001 |
| Calix of puncture | Lower (0), middle (1), upper (2) | 0.97 |
| Number of attempts to successful puncture | Numerical | 0.23 |
| Urine from puncture needle | Clear (0), hemorrhagic (1) | 0.48 |
| Method of tract dilatation | Balloon (0), Amplatz (1), Alken (2) | <0.0001 |
| Size of tract | Numerical | 0.001 |
| Number of tracts | Numerical | 0.003 |
| Intraoperative complications | No (0), yes (1) | <0.0001 |
| Operative time (min) | Numerical | <0.0001 |

[a]*P* value indicates significance of risk of increased blood loss in subset (1) or (2) compared with subset (0).
[b]Numerical = Actual values were considered.

urography (IVU) was done when the creatinine value was within the normal range.

The technical of PCNL employed is outlined below.

### *Access to the pelvicaliceal system*

Percutaneous renal access was obtained in the posterior axillary line using either ultrasound or fluoroscopy guidance with fluoroscopic confirmation.[12,13] The posterior calix from which the maximum stone bulk could be cleared and which gave direct access to the renal pelvis in a relatively straight line was chosen for primary access. The number of tracts created depended on the stone bulk and configuration and the pelvicaliceal anatomy. Tracts were dilated using either serial telescopic Alken dilators, sequential Amplatz dilators, or a single-step balloon dilator (Nephromax; Microvasive, Natick, MA). The size to which the tract was dilated depended on the pelvicaliceal anatomy (degree of hydronephrosis and infundibular width) and the stone bulk. A smaller (20F–22F) tract was employed in patients younger than 5 years and those with a nondilated pelvicaliceal system or narrow infundibulum. An Amplatz working sheath was placed in all cases.

### *Stone fragmentation*

Pneumatic lithotripsy (Swiss Lithoclast) was used for calculus disintegration in all cases.

### *Stage procedure*

The procedure was staged in patients with a large stone burden, prolonged nephroscopy time (>120 minutes), or presence

TABLE 4. EFFECT OF INTRAOPERATIVE COMPLICATIONS AND OPERATIVE TIME ON BLOOD LOSS

| | *Blood loss* | | |
|---|---|---|---|
| | *Hb drop (g/dL)* | *Hct drop (%)* | P *value*[a] |
| Complications | | | |
| Present (N = 24) | 3.38 ± 1.24 | 10.55 ± 4.25 | <0.0001 |
| Absent (N = 277) | 1.54 ± 1.08 | 5.03 ± 3.76 | |
| Operative time (min) | | | |
| 0–60 (N = 191) | 1.37 ± 1.03 | 4.4 ± 3.21 | <0.0001 |
| 61–120 (N = 95) | 2.2 ± 1.3 | 7.2 ± 4.9 | |
| >120 (N = 15) | 2.55 ± 1.3 | 7.69 ± 3.6 | |

[a]Stepwise multivariate regression analysis.

TABLE 5. EFFECT OF DEFERRED TRACT DILATATION IN SINGLE-TRACT PROCEDURES

| | Blood loss | |
|---|---|---|
| | *Hb drop (g/dL)* | *Hct drop (%)* |
| Nephrostomy with deferred tract dilatation (N = 40) | 0.81 ± 0.65 | 2.7 ± 1.7 |
| Puncture and dilatation in the same stage (N = 177) | 1.56 ± 1.07 | 5.17 ± 3.9 |
| *P* value[a] | <0.0001 | <0.0001 |

[a]Stepwise multivariate regression analysis.

of significant complications such as perforation or bleeding. An 18F to 20F nephrostomy drainage tube was placed through all unused tracts at the end of the primary procedure. As a result, all secondary percutaneous procedures were performed through mature tracts. Patients with significant uremia or pyonephrosis underwent initial nephrostomy tube placement only. In these cases, calculus removal was deferred to a subsequent stage after adequate control of infection and uremia. A KUB film was obtained 48 hours after the procedure to confirm the stone clearance status.

### *Estimation of blood loss*

Complete blood count (done 24 hours before and 48 hours after the procedure) and the number of units transfused (between the preoperative and the final blood count) determined the per-operative total blood loss (hemoglobin and hematocrit decrease). The approximation that 1 unit of blood transfused increases the hemoglobin level by 1.0 g/dL and the hematocrit by 3% was used to factor the influence of blood transfusion in estimation of blood loss. The total blood loss was calculated using the formula:

$$[(\text{preoperative Hb} - \text{postoperative HB}) + (\text{number of units transfused} \times 1 \text{ g/dL Hb per unit transfused})]$$

### *Factors assessed*

Both patient-related and procedure-related factors were assessed (Table 2).

Urinary infection was defined as a urine culture with a colony count of $\geq 10^5$. Hydronephrosis was graded as either absent, mild, moderate, or gross on the basis of the renal ultrasound scan and IVU.[14] Parenchymal thickness (mm) was measured at the planned calix of puncture (reported as the average in case of multiple tracts) on ultrasonography and IVU, respectively. The stone surface area ($mm^2$) was calculated by graph-paper tracing of the two-dimensional projection of the calculus on a plain film obtained in the anteroposterior view.[15]

Stones were categorized as pelvic (no caliceal involvement), multiple, upper-ureteral, partial staghorn, or complete staghorn. Partial staghorn calculi were defined as renal pelvic calculi with extension into at least two infundibula and calices. Complete staghorn calculi were defined as renal pelvic calculi with extension into all the calices and filling at least 80% of the collecting system.

Surgeon experience was graded in three categories. Category A was senior urologists with more than 10 years of experience in endourology who had performed more than 500 PCNLs. Category B was recently trained urologists with more than 3 years of experience in endourology who had performed more than 50 PCNLs. Category C was trainees with less than 3 years of experience in endourology having performed a minimum of 20 PCNLs.

The operative time was counted as the time from the puncture until the final placement of a nephrostomy tube. The association of total blood loss and transfusion requirement with the various factors was evaluated with stepwise multivariate regression analysis using the SPSS statistical analysis package. $P$ values $<0.05$ were considered significant.

## RESULTS

The average hemoglobin drop for all the procedures was 1.68 ± 1/2 g/dL (range 0.1–6 g/dL), whereas the average hematocrit drop was 5.46 ± 4.08% (range 0.4%–29%). When analyzed according to tract number, the average total blood loss was 1.42 ± 1.04 g/dL for single and 2.36 ± 1.3 g/dL for multiple tracts ($P = 0.003$).

Stepwise multivariate regression analysis revealed that the occurrence of operative complications ($P < 0.0001$), mature nephrostomy tract ($P < 0.0001$), operative time ($P < 0.0001$), method of access (fluoroscopy *v* ultrasonography) ($P =$

TABLE 6. EFFECT OF ULTRASOUND- VERSUS FLUOROSCOPY-GUIDED ACCESS ON BLOOD LOSS

| | Blood loss | | |
|---|---|---|---|
| | *Hb drop (g/dL)* | *Hct drop (%)* | P *value*[a] |
| Overall (N = 301) | | | |
| Ultrasound (N = 181) | 1.36 ± 1.04 | 4.4 ± 3.2 | <0.0001 |
| Fluoroscopy (N = 120) | 2.16 ± 1.27 | 7.01 ± 4.7 | |
| Single-tract single-stage procedures (N = 177) | | | |
| Ultrasound (N = 110) | 1.28 ± 0.9 | 4.1 ± 2.8 | <0.0001 |
| Fluoroscopy (N = 67) | 2.0 ± 1.2 | 6.8 ± 4.9 | |

[a]Stepwise multivariate regression analysis.

TABLE 7. EFFECT OF METHOD OF TRACT DILATATION ON BLOOD LOSS (SINGLE-TRACT PROCEDURES WITHOUT EXISTING TRACTS)

| | | Blood loss | |
|---|---|---|---|
| *Method of dilatation*[a] | N | *Hb drop (g/dL)* | *Hct drop (%)* |
| Balloon | 15 | 1.1 ± 0.7 | 3.2 ± 2.15 |
| Amplatz | 18 | 1.01 ± 1.14 | 2.8 ± 3.57 |
| Alken | 144 | 1.67 ± 1.07 | 5.6 ± 3.98 |

[a]Statistical analysis using univariate student's *t*-test: Amplatz *v* Alken $P = 0.008$ and $P = 0.003$; Amplatz *v* balloon: $P = 0.40$ and $P = 0.36$; Alken *v* balloon $P = 0.02$ and $P = 0.01$. Multivariate regression analysis 0.0001.

0.0001), method of tract dilatation ($P = 0.0001$), multiple tracts ($P = 0.003$), size of the tract ($P = 0.001$), parenchymal thickness ($P = 0.05$), and diabetes ($P = 0.05$) were significantly predictive of blood loss (Table 3). Intraoperative complications, operative time, and staged procedure were the most significant factors (Tables 3, 4, and 5). Intraoperative complications (N = 24) consisted of significant infundibular tear in 17 cases, pelvic wall tear in 3, and slippage of the Amplatz sheath out of the parenchyma in 4.

Age, hypertension, presence of urinary infection, renal insufficiency, function of the ipsilateral renal unit, degree of hydronephrosis, and stone surface area did not correlate with bleeding (see Table 3). Of the technical factors, the experience of the operating endourologist, the calix of access, number of attempts required to a successful puncture, and return of hemorrhagic urine from the puncture needle did not correlate with the degree of bleeding (Table 3).

The overall blood transfusion rate for all patients was 7.97%. Stepwise multivariate regression analysis with blood transfusion requirement as the response variable revealed the level of preoperative hemoglobin, stone surface area, multiple tracts, and the total blood loss to be predictive of blood transfusion requirements ($P < 0.001$).

## DISCUSSION

A PCNL is the treatment modality of choice for large-volume renal calculous disease. It has the advantages of better stone clearance, cost-effectiveness, and early convalescence compared with other modalities such as SWL and open surgery.[1] However, bleeding is a significant morbidity reported with PCNL.[1–11] Kessaris and associates[3] reported a 0.8% incidence of post-PCNL bleeding necessitating embolization. Blood loss during the procedure is often unnoticed and underestimated. Stoller and colleagues[4] reported that the surgeon-estimated blood loss was significantly lower than the calculated total blood loss. The overall blood loss should take into account the postoperative hemoglobin decrease combined with the number of blood transfusions required. Postoperative hemoglobin levels may not be at equilibrium, depending on the hemostatic and hydration status of the patient. Our use of the last available hemoglobin data (at least 48 hours post-procedure) before hospital discharge or the next procedure was an attempt to minimize hydration artifacts from intravenous fluid administration and absorption of retroperitoneal fluid. Additionally, concurrent estimation of hematocrit decrease may correct for the effect of hemodilution.

Bleeding during PCNL results from injury to renal vessels.[2–4] Excessive bleeding can occur during needle passage, tract dilatation, and nephroscopy or in the postoperative period.[3] Being a minimally invasive modality, direct control of bleeding through the PCNL tracts is generally not possible. The mainstay of reducing bleeding is meticulous operative technique and identification and possible modification of factors that may increase or decrease bleeding.

Establishing optimal percutaneous access appears to be the key determinant of PCNL-related blood loss. The factors in achieving percutaneous access include the initial puncture, the calix of entry, the method of tract dilatation, and the extent of dilatation. The operator (urologist or the radiologist) and the imaging guidance (ultrasound or fluoroscopy) are the two important considerations in the initial puncture. Lam et al[16] emphasized the importance of the urologist rather than the radiologist performing the puncture by showing a significant difference in the transfusion rate (0 *v* 11%, respectively). We perform punctures ourselves, as we firmly believe that the endourologist has a complete understanding of the intrarenal anatomy, especially the relation between the vasculature and the

TABLE 8. EFFECT OF TRACT SIZE ON BLOOD LOSS (SINGLE-TRACT PROCEDURES WITHOUT EXISTING TRACTS)

| | *Tract size (F)* | *Blood loss (g/dL)* | P *value*[a] |
|---|---|---|---|
| All patients | ≤22 (N = 35) | 1.1 ± 0.7 | 0.002[b] |
| | ≥26 (N = 136) | 1.66 ± 1.1 | |
| Patients with nil or | ≤22 (N = 20) | 1.13 ± 0.8 | 0.02[b] |
| mild hydronephrosis | ≥26 (N = 89) | 1.7 ± 1.16 | |

[a]Univariate Student's *t*-test.
[b]Multivariate regression analysis 0.001.

TABLE 9. EFFECTS OF SINGLE- AND MULTIPLE-STAGE PROCEDURES WITH MULTIPLE-TRACT PROCEDURES FOR COMPLEX AND STAGHORN CALCULI

| | *Multiple fresh tracts* | *Staged nephrostomies with deferred tract dilatation* | P *value*[a] |
|---|---|---|---|
| No. of patients | 50 | 10 | |
| Average age (years) | 42.9 ± 13.9 | 40.9 ± 7.4 | 0.33 |
| Stone bulk ($mm^2$) | 1044.2 ± 838.9 | 1364 ± 820 | 0.13 |
| Ave. no. of tracts | 2.58 ± 0.8 | 3.00 ± 0.9 | 0.08 |
| Ave. no. of stages | 1.4 ± 0.6 | 1.8 ± 0.8 | 0.05 |
| Ave. operating time (min) | 1192 ± 68.1 | 154.5 ± 53.2 | 0.07 |
| Mean Hb drop (g/dL) | 3.28 ± 1.42 | 1.77 ± 1.17 | 0.001 |
| Mean Hct drop (%) | 10.45 ± 4.95 | 5.74 ± 3.22 | 0.003 |

[a]Univariate Student's *t*-test.

collecting system. The initial puncture could be made using either ultrasound or fluoroscopy guidance. An ideal puncture should be straight, traversing the shortest distance from the skin to the target calix and then to the infundibulum and the renal pelvis in a straight line. This would transverse the minimum distance through the cortex and potentially avoid the larger renal vessels, which are generally closely related to the anterior and posterior surfaces of the major caliceal infundibula and the necks of minor calices.[2] An oblique tract, on the other hand, may damage a significant vessel. Multivariate analysis revealed ultrasound-guided access to be associated with significantly less blood loss than fluoroscopy-guided access ($P = 0.0001$) (Tables 3 and 6). Fluoroscopy-guided access requires imaging in two planes alternately with adjustments made independently with the X-ray beam perpendicular and parallel to the puncture needle. In contrast, ultrasonography offers real-time three-dimensional monitoring of the puncture, including the needle and the collecting system, in the same plane, thereby minimizing the chance of segmental vessel injuries. The efficacy and safety of ultrasound-guided access performed by urologists and radiologists has been well documented in several studies.[4,17–22] The calix of entry (lower, middle, or upper) and the number of attempts required to produce a successful puncture did not affect the blood loss significantly ($P = 0.93$ and 0.39, respectively). This proves that a straight tract from the skin to the cup of the calix and then to the pelvis is important irrespective of the calix punctured.

Stoller and colleagues[4] compared telescopic metal and single-step balloon dilatation for effect on blood loss and found no significant difference. Bellman and Davidoff,[23] however, found the Amplatz dilatation system to be associated with significantly more blood loss than balloon dilatation. We compared all three methods of tract dilatation: Amplatz serial dilators, Alken telescoping metal dilators, and the Nephromax balloon. The Amplatz system was associated with the least blood loss. However, the difference was statistically significant only when comparing the Amplatz or balloon with the Alken system ($P = 0.008$ and 0.02, respectively) (Tables 3 and 7). The Amplatz system, with its beveled-edge fascial dilators, spreads the parenchymal tissue rather than lacerating it.

Using a smaller tract may reduce bleeding during PCNL.[1,24,25] We routinely dilate the tract 28F. Larger tracts (30F–32F) are reserved for grossly hydronephrotic kidneys with a large stone bulk to facilitate removing larger fragments. Increasing the tract size (20F–32F) significantly affects the total blood loss, as seen in our series ($P = 0.001$). Smaller tract size probably is less traumatic in kidneys with nondilated calices and narrow infundibula. We selected patients with a single fresh percutaneous tract and assessed the impact of the size of the tract on bleeding. Tract size ≤22F was associated with less blood loss than standard dilatation to 28F and above (Table 8). In a significantly hydronephrotic collecting system with a large stone bulk, the advantage of a small tract may be negated by the extra time required for stone fragmentation and removal. We feel that a smaller tract may be beneficial in pediatric patients, patients with a nondilated pelvicaliceal systems, and for accessory tracts during multitract procedures where the main stone bulk has already been removed through the larger primary tract.

The presence of a large stone burden or complications such as significant perforation of the pelvicaliceal system and intraoperative bleeding associated with hypotension are indications to stage the procedure. In a staged procedure, a nephrostomy

TABLE 10. EFFECT OF NUMBER OF TRACTS ON BLOOD LOSS

| *Number of tracts*[a] | N | *Blood loss (g/dL)* | *Transfusion rate (%)* |
|---|---|---|---|
| 1 | 217 | 1.4 ± 1.05 | 10 (4.6) |
| 2 | 58 | 2.44 ± 1.23 | 6 (10.3) |
| >2 | 26 | 2.19 ± 1.48 | 8 (30.7) |

[a]Univariate analysis using student's *t*-test: single *v* 2 tracts $P < 0.0001$ and $P < 0.0001$; single *v* >2 tracts $P = 0.0003$ and $P < 0.0001$; 2 *v* >2 tracts $P = 0.21$ and $P < 0.0001$. Multivariate regression analysis: single *v* multiple tracts $P < 0.006$ and $P < 0.0001$.

Table 11. Effect of Stone Bulk ($mm^2$) on Blood Loss and Transfusion Rate

| | *500* (N = *187)* | *500–1000* (N = *82)* | *1000* (N = *32)* | P *value*[a] |
|---|---|---|---|---|
| Hb drop (g/dL) | 1.52 ± 1.06 | 1.84 ± 1.26 | 2.22 ± 1.6 | 0.03 |
| Hct drop (%) | 4.92 ± 3.3 | 6.17 ± 5.01 | 6.8 ± 5.01 | 0.06 |
| Transfusion (%) | 3 (1.6) | 11 (13.4) | 10 (31.2) | <0.0001 |

[a]Stepwise multivariate regression analysis.

tube is placed through all unused accesses, thereby allowing subsequent manipulations to be performed through a mature tract. A previously created nephrostomy allows the tract along the ruptured vessels to mature and heal. Sequential dilatation of this tract 48 hours later may cause less trauma, leading to reduced bleeding and better vision during nephroscopy, thereby reducing the operative time. The combination of reduced bleeding and shorter operative times may be responsible for the significantly reduced blood loss seen in our study ($P < 0.0001$) (see Table 5). We subdivided multiple-tract procedures into those performed with multiple fresh tracts (puncture, dilatation, and nephroscopy in the same stage) and those done through multiple tracts with previously created nephrostomies (all punctures made initially, either none or only one tract dilated for stone removal at the primary sitting, 18F–20F nephrostomy tube placed in the remaining unused tracts that were dilated during the secondary procedure performed after 48 hours (Table 9). The blood loss was much less during the staged procedures than the single-stage procedures ($P = 0.001$).

Multiple tracts are often required to clear complex and staghorn calculi with complex caliceal patterns. Bleeding and transfusion rates are greater with multiple tracts.[4,11] We performed multiple-tract procedures in 84 renal units (27.9%) with an average blood loss of 2.36 ± 1.3 g/dL and a transfusion rate of 16.6%. This was significantly higher than that in procedures performed through a single tract ($P < 0.0001$) (Tables 3 and 10). The difference between the blood loss in procedures requiring two tracts (2.44 ± 1.23 g/dL) and those needing three tracts (2.19 ± 1.48 g/dL) was not significant ($P = 0.2$). This may be because we routinely staged the procedures that required more than two tracts.

Technical complications may lead to excessive bleeding.[4] These include pelvicaliceal tears and loss of the access tract. Infundibular tears may occur during tract dilatation or stone manipulation and may be associated with laceration of significant vessels that lie close to the infundibulum. Subsequent instrument manipulation in that area is likely to enlarge the tear and further traumatize the injured vessel, leading to hemorrhage. Staging the procedure in such cases, especially when dealing with complex calculi or when a significant stone burden is yet to be removed, allows the injury to heal and reduces the blood loss at a subsequent stage. Loss of percutaneous access can lead to loss of tract tamponade and uncontrolled bleeding from the renal parenchyma. Initial guide and safety wires should be placed and secured carefully. Retraction of the working sheath into the renal parenchyma should be minimized. Significant complications occurred in 24 patients in our series (infundibular tear in 17, pelvic wall tear in 3, and slippage of the Amplatz sheath out of the parenchyma in 4). These patients with a complication had significantly greater blood loss (2.2 times) than those having uncomplicated procedures (see Tables 3 and 4).

Of the various patient-related factors, age and hypertension did not significantly affect blood loss. Bleeding complications have been suggested to be greater in patients with renal insufficiency (creatinine >1.5 mg/dL) or hypertension who undergo percutaneous renal biopsy. We did not find any increase in bleeding in either of these conditions. Diabetic patients, however, were found to be prone to increased blood loss (Tables 3 and 11). Associated arteriosclerosis with thickened basement membranes may make such patients more prone to bleeding after the initial trauma of tract formation.[2] The role of prior intervention (open operation or PCNL) as a risk factor for increased blood loss during PCNL has been controversial. Netto and associates[5] identified prior surgery as a risk factor for increased bleeding, but Stoller and colleagues,[4] in their retrospective analysis, did not find any significant difference in blood loss in patients with and without a history of SWL or open surgery. On the contrary, we found a significant decrease

Table 12. Effect of Diabetes and Parenchymal Thickness on Blood Loss

| | *Blood loss* | | |
|---|---|---|---|
| | *Hb drop (g/dL)* | *Hct drop (%)* | P *value*[a] |
| Diabetes | | | |
| Yes (N = 31) | 1.98 ± 1.38 | 7.12 ± 5.1 | 0.05 |
| No (N = 270) | 1.64 ± 1.18 | 5.27 ± 3.9 | |
| Parenchymal thickness (mm) | | | |
| <10 (N = 49) | 1.31 ± 1.04 | 4.2 ± 3.07 | 0.05 |
| >10 (N = 252) | 1.76 ± 1.2 | 5.7 ± 4.2 | |

[a]Stepwise multivariate regression analysis.

in blood loss in patients with a history of PCNL or open surgery. This finding, although surprising, could be attributed to the likelihood of reduced renal cortical thickness in these cases. Smith[26] had proposed thin, scarred pyelonephritic cortex to be associated with reduced bleeding. Multivariate analysis of our data supports this statement ($P = 0.05$) (Tables 3 and 11). Cortical thinning with reduced blood flow may be responsible for this observation.

Stone surface area did significantly affect blood loss ($P = 0.03$) but correlated more significantly with the transfusion rate ($P = 0.0001$) (Table 12). Staging the procedure for removal of large calculi may offset the correlation with blood loss. As such, the total blood loss from all the stages may be higher and be reflected in a higher transfusion rate. None of the other patient-related factors (urinary infection, functional status of the ipsilateral unit, or the degree of hydronephrosis) had any significant impact on blood loss.

In our study, the most important risk factor associated with blood transfusion requirement was existing anemia, which emphasizes that the transfusion rate depends on the population studied. The blood loss, stone surface area, and multiple tracts were other factors that affected the transfusion rate.

## CONCLUSIONS

Diabetes, multiple-tract procedures, prolonged operative time, and intraoperative complications are associated with significantly greater blood loss during PCNL. Atrophic parenchyma and past ipsilateral surgical intervention are associated with reduced blood loss. Recommended maneuvers that may reduce the blood loss and transfusion rate during PCNL are:

Ultrasound-guided access;
Use of Amplatz or balloon dilatation systems;
Staging the procedure in select patients;
Reducing the caliber of the percutaneous tract in children and patients with nondilated collecting systems with a narrow infundibulum and for secondary tracts in multiple-tract procedures.

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