Original Article

Effects of fluid absorption following percutaneous nephrolithotomy: Changes in blood cell indices and electrolytes

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Abstract

Background and Aims: Effects of fluid absorption on hematological profile in the immediate postoperative period in patients undergoing percutaneous nephrolithotomy (PCNL) have not been given due importance. Considering the limited number of studies available, we conducted this study to evaluate the changes in hemodynamics, complete blood count (CBC), and electrolytes in patients undergoing PCNL using normal saline for irrigation in the prone position. Furthermore, we evaluated the common factors known to affect the absorption.

Materials and Methods: Forty American Society of Anesthesiologist Class I or II patients aged 18–65 years were recruited who underwent PCNL under general anesthesia. Heart rate, blood pressure (BP), CBC, and serum electrolytes were recorded preoperatively and just before extubation and compared using the Student's *t*-test. Correlation of these changes with height and total volume of irrigating fluid, total time of irrigation, duration of operation, and total intravenous fluids administered intraoperatively were performed using the Pearson's correlation coefficient.

Results: There was a statistically significant fall in mean hemoglobin (12.5 g/dL to 11.5 g/dL), packed cell volume (38.6%–35.6%), platelet count (2.9×10^5 cells/μL to 2.5×10^5 cells/μL), and sodium ion concentration (Na^+) (138.9 meq/L to 137.7 meq/L) in the immediate postoperative period as compared to that of the preoperative values. Rest of the blood indices and electrolytes did not show any significant change. There was a significant rise in postoperative heart rate and BP. Postoperative systolic BP showed a significant positive correlation with the total volume of irrigating fluid. No significant correlation was observed with height and total time of irrigation.

Conclusion: This study reveals that there is a significant fall in hemoglobin and Na^+ during PCNL in the immediate postoperative period. Only, total volume of irrigating fluid and total duration of surgery had a significant correlation with blood cell indices.

Keywords: Electrolytes, fluid absorption, hematology, percutaneous nephrolithotomy, postoperative

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INTRODUCTION

Evolving lifestyle has led to a global increase in the incidence and the prevalence of kidney stones.[1] Percutaneous nephrolithotomy (PCNL) remains the most commonly used technique in renal stones >2 cm despite the emergence of retrograde intra-renal surgery as an alternative.[2] Both, subarachnoid block as well as general anesthesia, are safer techniques for PCNL. Irrigating fluid absorption, bleeding, pneumothorax, and hydrothorax are common complications associated with PCNL making emergence from anesthesia challenging, especially in high-risk cases.[3]

Study conducted previously have established beyond suspicion that the absorption of irrigating fluid for both intravascular and extravascular, occurs invariably in all the patients during PCNL.[4] Extravascular absorption was found to have a worse prognosis as compared to that of the intravascular absorption. However, factors affecting the absorption are not identified as clearly as in transurethral resection of the prostate (TURP). Furthermore, the effects of absorption on immediate postoperative hematological profile have not been detailed. This study was planned with an objective to identify the factors responsible for the absorption of irrigating fluid and blood loss. We evaluated the hemodynamic changes, complete blood count (CBC), and electrolyte changes in patients undergoing PCNL using normal saline for irrigation in the prone position, and correlated these changes with height and the total volume of irrigating fluid, total time of irrigation, duration of surgery, and total intravenous fluids administered intra-operatively.

MATERIALS AND METHODS

This prospective study was conducted at a tertiary care institute after approval from the Institutional Ethics Committee over a period of 6 months. Forty American society of anesthesiologist (ASA) Class I or II adult patients of age group 18–65 years scheduled to undergo PCNL were selected. Patients who were not willing to participate for the various reasons, ASA Class III and IV, age <18 years, smokers, and those on drugs known to affect the hemodynamics or electrolytes were excluded from the study. Furthermore, patients who had more than one percutaneous intervention were excluded. An informed consent was obtained from the patients explaining them the whole procedure and the aim behind conducting the study. Preanesthetic checkup was conducted for all the patients.

Patients were kept nil by the mouth for 6–8 h before the procedure. In the operation theater, monitoring was instituted in the form of electrocardiography, noninvasive blood pressure (BP) measurement, pulse oximetry, and a large gauge intravenous line was secured. Preoperative heart rate and systolic BP (SBP) and diastolic BP were recorded. Preoperative CBC with indices such as hemoglobin, total red blood cell count (RBC), packed cell volume (PCV), mean corpuscular volume, mean corpuscular hemoglobin (MCH), MCH concentration, total leukocyte count, platelet count, and serum sodium (Na^+) and potassium (K^+) values were also recorded.

Induction and maintenance of anesthesia were done as per the standard protocol. Ringer's lactate solution was infused for intravenous fluid administration according to the requirement. After inserting a ureteric catheter in the lithotomy position, the patient was turned to the prone position. A 20G percutaneous needle was used to access the renal collecting system under c-arm guidance. The tract was dilated by semi-rigid dilators up to 26 F and working Amplatz sheath was placed. Fragmentation and extraction of stones were performed by a rigid nephroscope passed through this sheath. Normal saline was used for continuous irrigation of the kidney. On completion of the procedure, patients were extubated after adequate reversal. The height of irrigating fluid, total volume of irrigating fluid, total time of irrigation, total duration of surgery, and total fluids administered intravenously during the intraoperative period were recorded. Postoperative heart rate, SBP, and diastolic BP were recorded for 5 min after the extubation. Blood samples were drawn immediately before extubation to measure the postoperative-CBC and serum Na^+ and K^+ values.

The primary aim of this study was to compare the various blood cell indices and electrolytes preoperatively and immediately after surgery. The secondary aim was to correlate the changes observed with common factors known to alter fluid absorption.

A sample size of 40 was found to be adequate for a power of 80%. Student's *t*-test and paired *t*-test were used for preoperative and postoperative comparisons of CBC and electrolytes. Pearson's correlation was used to establish a linear correlation between different variables. A value of $P < 0.05$ was considered as statistically significant.

RESULTS

Of the 40 patients included in this study, 17 (42.5%) were female and 23 (57.5%) were male. Mean age of the patients was 37.72 years. The demographic and surgical variables are shown in Table 1. Only three patients

had comorbidities such as hypertension, diabetes, or hypothyroidism for which treatment was being given. Comparison of laboratory values preoperatively and postoperatively shows a statistically significant drop in hemoglobin (Hb), RBC, PCV, platelets, and serum Na^+ [Table 2]. In this study, maximum drop in Hb of about 2.4 g/dL was observed with a mean drop of 0.92 g/dL ($P < 0.05$) Although we did not require blood transfusion during the procedure, five (12.5%) of the patients required blood on postoperative day 1 or 2. Although white blood cells (WBC) count did not show significant change, 10 of the patients had WBC >10,000/cu mm.

There was a significant increase in both SBP and diastolic BP and heart rate [Table 3]. Correlation of the difference of preoperative and postoperative values of laboratory data and hemodynamic variables which had shown significant changes was done with height of irrigating fluid, total irrigating fluid used, total time of irrigation, total duration of surgery, and total intravenous fluid used intra-operatively [Table 4]. Only, total volume of irrigating fluid and total duration of surgery had a significant negative correlation with fall in PCV and total RBC. The height of the irrigating fluid ranged from 44 to 142 cm, whereas total irrigating fluid used was between 1.2 and 40 L.

Table 1: Demographic and surgical parameters studied

	Range (mean)
Age (years)	22-65 (37.725)
Sex (%)	
Male	23 (52.5)
Female	17 (42.5)
ASA	
I	37
II	3
Duration of surgery (min)	30-240 (107.675)
Duration of irrigation (min)	19-240 (54.75)
Volume of irrigation fluid (L)	1.2-40 (13.76)
Height of irrigation (cm)	44-142 (102.025)
Volume of intravenous fluid (L)	0.5-1.5 (1.44)

ASA: American Society of Anesthesiologists

Table 2: Comparison of pre- and post-operative laboratory data

	Preoperative	Postoperative	*P*
Hb (g/dL)	12.545±1.740	11.645±1.872	0.000*
RBC (million/μL)	4.493±0.751	4.144±0.721	0.000*
PCV (%)	38.625±5.293	35.640±4.924	0.000*
MCV (fL/RBC)	86.52±11.10	85.75±11.98	0.301
MCH (g/dL)	28.076±4.302	28.252±4.490	0.560
MCHC (pg/RBC)	32.104±2.024	32.362±1.367	0.403
TLC (cells/μL)	8533±1573	8673±3123	0.760
Platelet ($\times 10^5$ cells/μL)	2.864±0.928	2.485±0.841	0.000*
Na^+ (meq/L)	139.875±4.220	137.725±4.188	0.001*
K^+ (meq/L)	4.3410±0.5291	4.2813±0.4442	0.559

*Statistically significant ($P<0.05$). Hb: Hemoglobin, RBC: Red blood cell, PCV: Packed cell volume, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, TLC: Total leukocyte count

Table 3: Comparison of pre- and post-operative hemodynamic parameters

	Preoperative	Postoperative	*P*
Mean HR	90.20±13.32	97.38±17.22	0.024*
Mean SBP (mmHg)	127±14.56	139.45±15.19	0.000*
Mean DBP (mmHg)	77.15±9.40	89.35±15.43	0.000*

*Statistically significant ($P<0.05$). HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

DISCUSSION

Fluid absorption during TURP has been studied in detail and various factors affecting it have been established beyond suspicion. However, fluid absorption during PCNL has been proved in limited studies.[4-8] Besides, none of the studies have shown the effect of hemodilution in immediate postoperative period. The aim of this study was to compare the preoperative and postoperative hemodynamic parameters, serum electrolytes, and CBC in patients undergoing PCNL under general anesthesia. We also set out to determine the various factors that might show any correlation to changes in blood cell indices and hemodynamics during PCNL. We found that Hb, RBC, PCV, and platelets were the only blood cell indices to show statistically significant difference in preoperative and postoperative values. Both heart rate and BP (systolic as well as diastolic) increased significantly in the postoperative period.

It is known that laboratory values do not change forthrightly after acute blood loss until redistribution of interstitial fluid occurs into the blood plasma after 8–12 h.[9] Since the blood sample was collected immediately after the completion of the procedure, intraoperative blood loss cannot account for the alteration in blood cell indices. Hence, we concluded that the statistically significant fall in Hb, RBC, PCV, and platelets noted in this study was mainly due to hemodilution secondary to either irrigating fluid absorption or intravenous fluid replacement. Grathwohl *et al.* have demonstrated that there is no hemodilution in patients receiving maintenance intravenous fluid.[10] However, when a bolus of around 30 ml/kg/h crystalloid, especially saline is given, there is a marked hemodilution as noted by the Hb and hematocrit values. This remains until 8 h of administration. We had given an average of 1.44 L of intravenous fluid over an average duration of 108 min depending on the hydration status and hemodynamic variables (10–15 ml/kg/h). Furthermore, in this study, no correlation was seen between the total IV fluid given and changes in blood cell indices. Hence, it can be safely concluded that the fall in Hb noted is predominantly due to irrigating fluid absorption.

Table 4: Correlation of various parameters studied

	Height of irrigating fluid		Total irrigating fluid		Total time of operation		Total time of irrigation		Total intravenous fluid	
	R	*P*	*R*	*P*	*R*	*P*	*R*	*P*	*R*	*P*
HR (/min)	0.166	0.306	0.072	0.658	−0.117	0.474	−0.149	0.359	−0.013	0.938
SBP (mmHg)	0.004	0.980	0.353	0.025*	0.039	0.811	0.025	0.880	0.025	0.877
DBP (mmHg)	0.066	0.683	0.234	0.146	0.303	0.057	1.175	0.281	−0.029	0.858
Hb (g/dl)	0.063	0.701	−0.099	0.542	−0.127	0.435	−0.139	0.393	−0.187	0.247
PCV (%)	−0.170	0.294	−0.523	0.001*	−0.365	0.02*	−0.263	0.101	−0.172	0.287
Platelet ($\times 10^5$ cells/μL)	−0.231	0.151	0.039	0.811	0.065	0.688	−0.025	0.819	−0.153	0.346
RBC (million/μL)	−0.102	0.533	−0.427	0.006*	−0.312	0.050	−0.161	0.322	−0.229	0.156
Na^+ (meq/L)	0.141	0.387	−0.090	0.579	−0.082	0.614	−0.188	0.244	−0.099	0.545

*Statistically significant ($P<0.05$). HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, PCV: Packed cell volume, Hb: Haemoglobin, RBC: Red blood cell

In this study, the amount of irrigating fluid used and duration of anesthesia were the only two factors showing significant correlation with changes in hemoglobin, RBC, PCV, and SBP similar to the conclusions drawn by Kukreja *et al*.[5] and recently by Guzelburc *et al*.[11] However, our study also shows that the height of irrigating fluid and total time for irrigation do not show any correlation with the above-mentioned indices. Height of irrigating fluid is an important determinant of fluid absorption during the TURP.[12] The average irrigating fluid absorbed as noted in the study by Kukreja *et al*. was 178 mL with maximum absorption of 474 mL.[5]

In this study, maximum fall in Hb of about 2.4 g/dL was noted. Thus, patients with previously borderline Hb tend to show a critical drop due to hemodilution. To compensate for nil by the mouth status and ongoing blood loss, there is a tendency toward over replacement of fluid during surgery. This can prove deleterious in patients with impaired cardiopulmonary reserve. Thus, it is recommended that fluid be administered under strict vigilance during PCNL. Saline should be avoided as far as possible.

There was a significant increase in the heart rate and BP postoperatively [Table 3]. However, this rise can be predominantly attributed to sympathetic stimulation during extubation. The role of fluid absorption cannot be commented on. Studies done before did not find any statistically significant changes in postoperative hemodynamic variables.[7-9]

This study shows that there was a tendency toward fall in predominant electrolytes Na^+ and K^+ with only Na^+ showing statistically significant fall. However, the fall in serum electrolytes was not such as to warrant any correction. This observation is consistent with other studies.[6-8] Atici *et al*. found significant increases in renin, aldosterone, and adrenocorticotropic hormone levels during PCNL procedures.[6] They concluded that hyponatremia may be due to the invasive nature of the intervention to the kidney and the continuous irrigation of this vital organ. Reduction in platelet counts was also found to be statistically significant. Hypothermia along with hemodilution can alter platelet function.[13,14] This may add to the ongoing blood loss.

Although WBC count did not show any significant change, 10 patients had WBC count >10,000/cu mm. However, this finding had no correlation to the development of fever postoperatively. Nine of the 40 patients developed fever postoperatively. They had WBC count within normal limits, but eight of them had duration of surgery of >120 min. This finding is consistent with the study done by Kukreja *et al*.[5]

The main limitation of this study was that ethanol testing was not done along with CBC. All the known factors responsible for absorption, such as tract size and locations, were also not taken into consideration. Larger studies with ethanol testing for absorption and immediate postoperative laboratory investigations will give a complete picture of the consequences of fluid absorption.

CONCLUSION

This study while supporting the findings of previous studies, adds to the existing evidence by showing that the height of irrigating fluid and total time for irrigation do not affect the amount of fluid absorption. Measures to reduce the volume of irrigating fluid and decreasing the total duration of the procedure should be taken. Intravenous fluid should be given judiciously. Diuretics should be used, especially in patients with diminished cardiorespiratory reserves.

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Conflicts of interest
There are no conflicts of interest.

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