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COMPARISON OF INTRAOPERATIVE BLOOD LOSS IN PATIENTS WITH AND WITHOUT PREVIOUS OPEN RENAL STONE SURGERY ON IPSILATERAL SIDE UNDERGOING PERCUTANEOUS NEPHROLITHOTOMY

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Abstract

Background: *Percutaneous nephrolithotomy (PCNL) is the gold standard for treating kidney stones larger than 20 mm, but blood loss remains a significant complication. Previous open renal stone surgery (POS) has been reported as a risk factor for increased blood loss during PCNL. This study aimed to compare intraoperative blood loss in patients with and without a history of POS undergoing PCNL.*

Objective: *To compare the intraoperative blood loss in patients with a history of previous open renal stone surgery (POS) versus patients without a history of POS undergoing percutaneous nephrolithotomy (PCNL).*

Method: *This quasi-experimental study was conducted at the Department of Urology, Sir Ganga Ram Hospital, Lahore, Pakistan, from January to December 2021. Sixty-eight patients were divided into two groups of 34 each: Group A with a history of POS on the ipsilateral side and Group B with primary PCNL. Demographic details, stone characteristics from non-contrast CT scans, and complete blood counts before and after PCNL were recorded. Blood loss was calculated based on the difference in pre- and postoperative hemoglobin levels and the number of blood pints transfused. Data were analyzed using SPSS version 26.*

Result: *The average age in Group A was 50.0±7.9 years and in Group B was 41.2±11.3 years. There were no significant differences in gender distribution, stone location, or stone size between the groups. The mean drop in hemoglobin level was 0.34±0.21 g/dl in Group B and 0.23±0.33 g/dl in Group A (p=0.265). Three patients (8.8%) in Group A required blood transfusion postoperatively, compared to none in Group B (p=0.076). The median hospital length of stay was significantly longer in Group A (4.0 days) than in Group B (3.0 days) (p=0.042).*

Conclusion: *PCNL is an effective and safe procedure for treating kidney stones* *in patients with or without a history of POS in terms of blood loss. However, patients with a history of POS may have a longer hospital stay.*

INTRODUCTION

Kidney stone is a common urological disease that affects about 12% of global population.[1] Its etiology is multifactorial; and mechanism is complex resulting from several physio-chemical events.[2] Its signs and symptoms include flank pain, hematuria, nausea and vomiting.[3] Higher risk of stone formation is associated with some chronic conditions such as cystic fibrosis, inflammatory bowel disease, and urinary tract infections.[4] Renal stone is a recurrent disease with chance of recurrence of 50% in 5 years.[5] Most stones are primarily made of calcium oxalate. Increased fluid intake and lifestyle modifications such as preventing higher intake of oxalate, sodium and protein diet are associated with reduced risk of calcium stones.[6] Stones can result in loss of renal functions,[7] which results in an increased risk of end-stage renal disease.[8] It is more frequently seen in adults than children; and in males than females (males 11% and females 7%).[4] Treatment options for renal stone include expulsive medical therapy and minimally invasive renal surgery.

Percutaneous nephrolithotomy (PCNL) is a minimally invasive procedure which is the gold standard for treatment of single large or multiple renal stones and those in the inferior calyx.[9] PCNL causes minimal damage on the renal functions, and prevents the progression of end-stage renal disease.[10] However PCNL is a cost effective procedure with lower morbidity but its complications include adjacent organ damage, blood loss, pyelonephritis and increase need for blood transfusion.[11] During surgery bleeding occurs due to injury of segmental and interlobar vessels during multiple tracts for dilation, large and complex renal stones, prolonged operative time, renal pelvi-calyceal perforation and misplacement of nephrostomy tube.[12] The volume of blood loss is indirectly measured and expressed in the form drop in hemoglobin. Patients with previous open surgery, however, had a greater drop in haemoglobin (weighted mean difference (WMD), 1.78 g/L and higher risk of bleeding that required angiographic embolisation (relative risk (RR 3.73). Hence bleeding is a significant complication of PCNL during surgery and blood transfusions are frequently required.[13]

METHODS

This study received ethical approval from the Ethics Review Committee (ERC) of Fatima Jinnah Medical University/Sir Ganga Ram Hospital, Lahore, Pakistan, and all participants provided written informed consent. The research was conducted over one year, from January to December 2021, at the Department of Urology, Sir Ganga Ram Hospital, Lahore, Pakistan, employing a quasi-experimental study design. A non-probability purposive sampling technique was used to select a sample size of 68 patients (34 per group), calculated based on expected blood loss rates with a 90% confidence level and 80% test power.

Inclusion criteria encompassed adult patients (18–60 years) of both genders with renal stones (10–30 mm), including those with and without a history of previous open renal stone surgery (POS) on the ipsilateral side. Exclusion criteria included bleeding disorders, anticoagulant use, significant comorbidities (obesity, DM, HTN, CKD, IHD), abnormal renal anatomy, immunocompromised status, pregnancy, active UTIs, and pre-operative Hb < 10.0 g/dL.

Intraoperative blood loss was assessed by comparing Hemoglobin (Hb) levels measured 24 hours before and 48 hours after Percutaneous Nephrolithotomy (PCNL), accounting for any blood transfusions using the approximation that 1 pint enhances Hb by 1.0 g/dL. The formula used was: Total Blood Loss (Drop in Hb level) = [Preoperative Hb - Postoperative Hb] + [Number of units transfused x 1.0 g/dL Hb per unit transfused]. Blood transfusions were initiated if Hb fell below 7.0 g/dL, aiming for a post-transfusion level of 7.0–9.0 g/dL, based on NICE guidelines and clinical assessment.

Data collection involved obtaining consent, categorizing 68 patients into Group A (with POS history) and Group B (primary PCNL), conducting routine preoperative tests, and recording demographic and clinical details. Stone characteristics were noted from CT scans. Preoperative Hb was measured from a 3cc blood sample using a Sysmex KX-21 analyzer. PCNL was performed under general anesthesia by a consistent surgical team, involving standard steps like ureteral catheter insertion, prone positioning, fluoroscopy-guided puncture, guidewire placement, tract dilation (up to 27 F), Amplatz sheath insertion (30 FR), pneumatic lithotripsy, stone removal, and nephrostomy tube placement. Stone-free status was defined as residual fragments ≤ 3 mm. Catheters were removed after 24 hours, and discharge typically occurred after 72 hours, with a one-week follow-up. Post-operative Hb was measured 48 hours after PCNL using another 3cc blood sample. Data was collected by the researcher on a proforma.

Data analysis was performed using SPSS version 26. Quantitative variables were reported as mean ± standard deviation, while qualitative variables were presented as frequencies and percentages. Independent sample t-tests compared means, and Chi-square tests compared frequencies between groups. A P-value ≤ 0.05 indicates statistical significance. Data normality was checked using the Shapiro-Wilk test.

RESULTS

The results of this study provide a comprehensive comparison of intraoperative and postoperative outcomes among patients undergoing PCNL, divided into two cohorts—those with and without a history of previous open renal stone surgery (POS) on the ipsilateral side. Across the 34 patients in each group, a detailed analysis was conducted covering demographic characteristics, clinical presentations, stone attributes, surgical metrics, hematologic changes, transfusion needs, hospital stay durations, and contributing risk factors.

Patients in the group with previous surgery were significantly older, with a mean age of 50.0±7.9 years, compared to 41.2±11.3 years in the non-surgical group ($p < 0.001$). The median ages reflected a similar trend: 49.5 years vs. 42.5 years, respectively. This age difference is visually represented in Figure 1, with detailed distribution given in Table 1.

Table 1 Age distribution of cases for two groups by previous surgery history

Age (years)	Group		P-value
	Without previous surgery	With previous surgery	
Mean	41.2	50.0	< 0.001
SD	11.3	7.9	
Median	42.5	49.5	
Q1	33.0	44.0	
Q3	48.0	57.0	

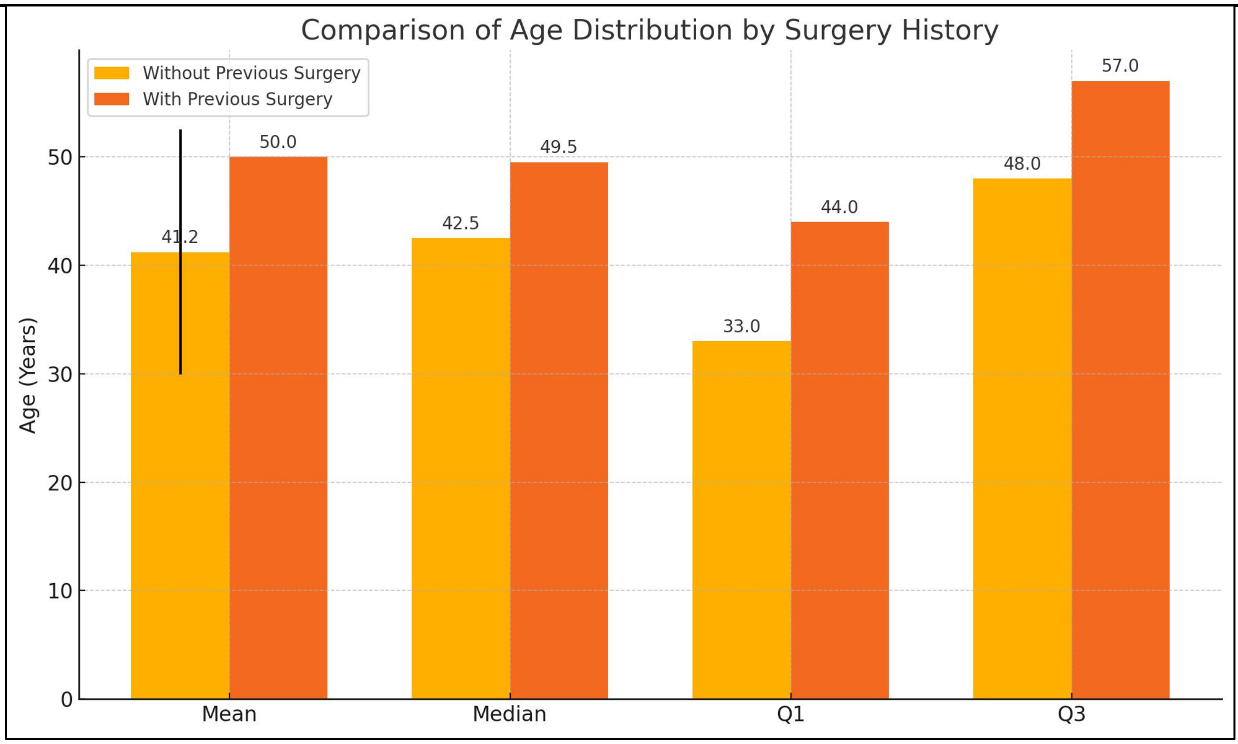

Figure 1

Gender distribution showed no significant difference between the groups (p = 0.808). There were 19 males (55.9%) in the non-surgical group and 18 males (52.9%) in the surgical history group. Female representation was nearly equal across both cohorts. Detailed in Table **2**.

Table 2 **Gender distribution of cases for two groups by previous surgery history**

Gender	Group			
	Without previous surgery		With previous surgery	
	Count	%	Count	%
Male	19	55.9	18	52.9
Female	15	44.1	16	47.1
Total	34	100.0	34	100.0

Chi-square = 0.06 P-value = 0.808

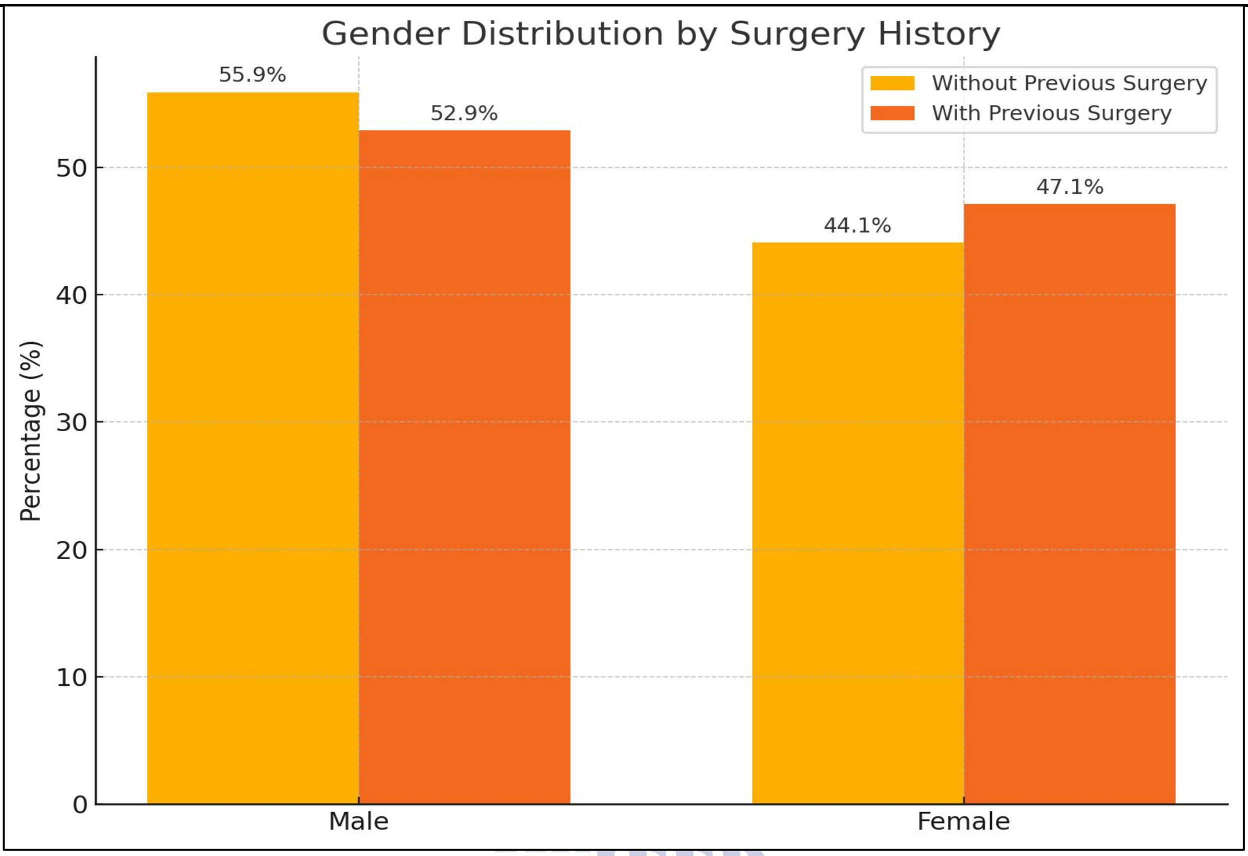

Figure 2

Flank pain was universally present in all patients of both groups (100%). Haematuria occurred in 11.8% of the non-surgical group and 8.8% of the surgical history group (p = 0.690). Dysuria was present in 14.7% and 23.5%, respectively, but again not statistically significant (p = 0.355).

Nausea/vomiting, the most common symptom besides flank pain, was equally prevalent at 29.4% in both groups (p = 1.000). History of passing stones in urine was reported by 11.8% in the non-surgical group vs. 5.9% in the surgical group (p = 0.393). Tables 3 to 7 support the clinical presentation findings, none of which showed significant group differences.

Table 3: Pain in flanks of cases for two groups by previous surgery history

	Group			
	Without previous surgery		With previous surgery	
	n	%	n	%
Yes	34	100.0	34	100.0
No	0	0.0	0	0.0
Total	34	100.0	34	100.0

Chi-square = 0.00 P-value = 1.000

Table 4: Haematuria of cases for two groups by previous surgery history

	Group			
	Without previous surgery		With previous surgery	
	n	%	n	%
Yes	4	11.8	3	8.8
No	30	88.2	31	91.2
Total	34	100.0	34	100.0

Chi-square = 0.16
P-value = 0.690

Table 5 Dysuria among cases for two groups by previous surgery history

	Group			
	Without previous surgery		With previous surgery	
	n	%	n	%
Yes	5	14.7	8	23.5
No	29	85.3	26	76.5
Total	34	100.0	34	100.0

Chi-square = 0.86
P-value = 0.355

Table 6 Nausea/ vomiting among cases for two groups by previous surgery history

	Group			
	Without previous surgery		With previous surgery	
	n	%	n	%
Yes	10	29.4	10	29.4
No	24	70.6	24	70.6
Total	34	100.0	34	100.0

Chi-square = 0.00
P-value = 1.000

Table 7 Passing of stone in urine among cases for two groups by previous surgery history

	Group			
	Without previous surgery		With previous surgery	
	n	%	n	%
Yes	4	11.8	2	5.9
No	30	88.2	32	94.1
Total	34	100.0	34	100.0

Chi-square = 0.73
P-value = 0.393

Right-sided kidney involvement was more frequent in the non-surgical group (70.6%) than in the surgical group (55.9%), though this difference was not statistically significant (p = 0.209). Refer to Table 8 for the complete breakdown.

Table 8 **Kidney affected among cases for two groups by previous surgery history**

	Group			
	Without previous surgery		With previous surgery	
	n	%	n	%
Right	24	70.6	19	55.9
Left	10	29.4	15	44.1
Total	34	100.0	34	100.0

Chi-square = 1.58 P-value = 0.209

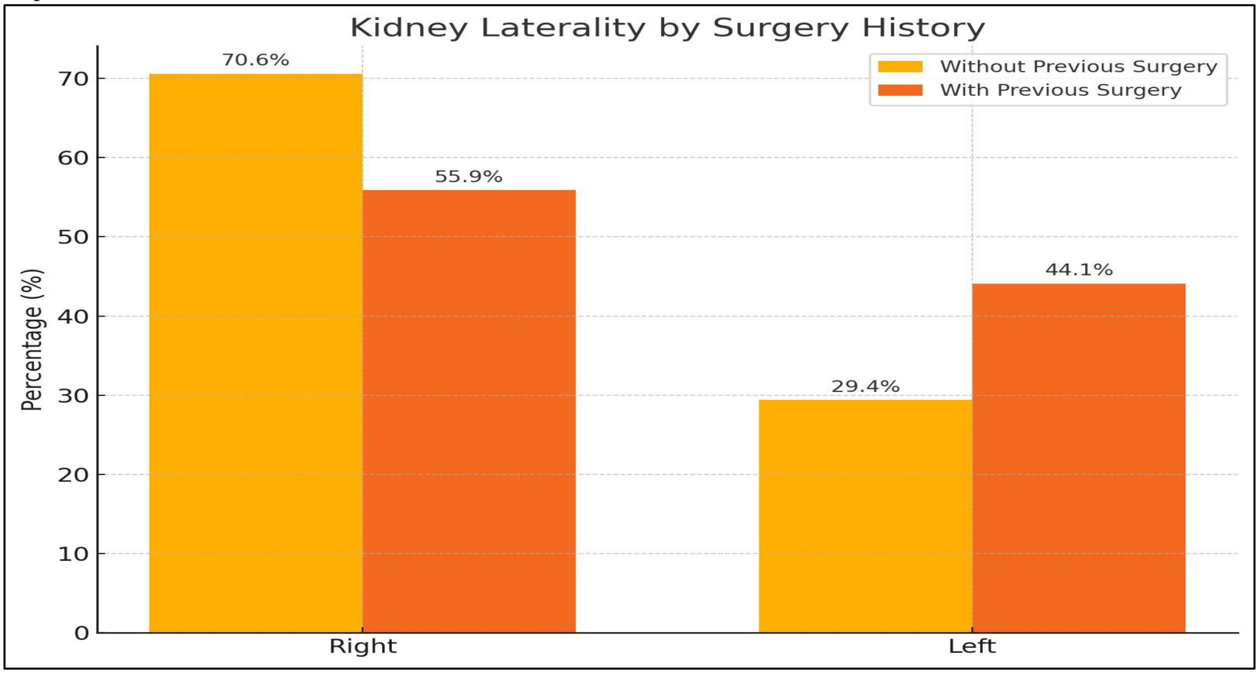

Figure 3

The pelvic location of stones was predominant in both groups (67.6% and 64.7%, respectively), followed by upper and middle/lower pole locations. However, this pattern showed no significant difference (p = 0.963), as displayed in Table 9.

Table 9 **Location of stone among cases for two groups by previous surgery history**

	Group			
	Without previous surgery		With previous surgery	
	n	%	n	%
Pelvic	23	67.6	22	64.7
Upper	9	26.5	10	29.4
Middle or lower pole	2	5.9	2	5.9
Total	34	100.0	34	100.0

Chi-square = 0.08 P-value = 0.963

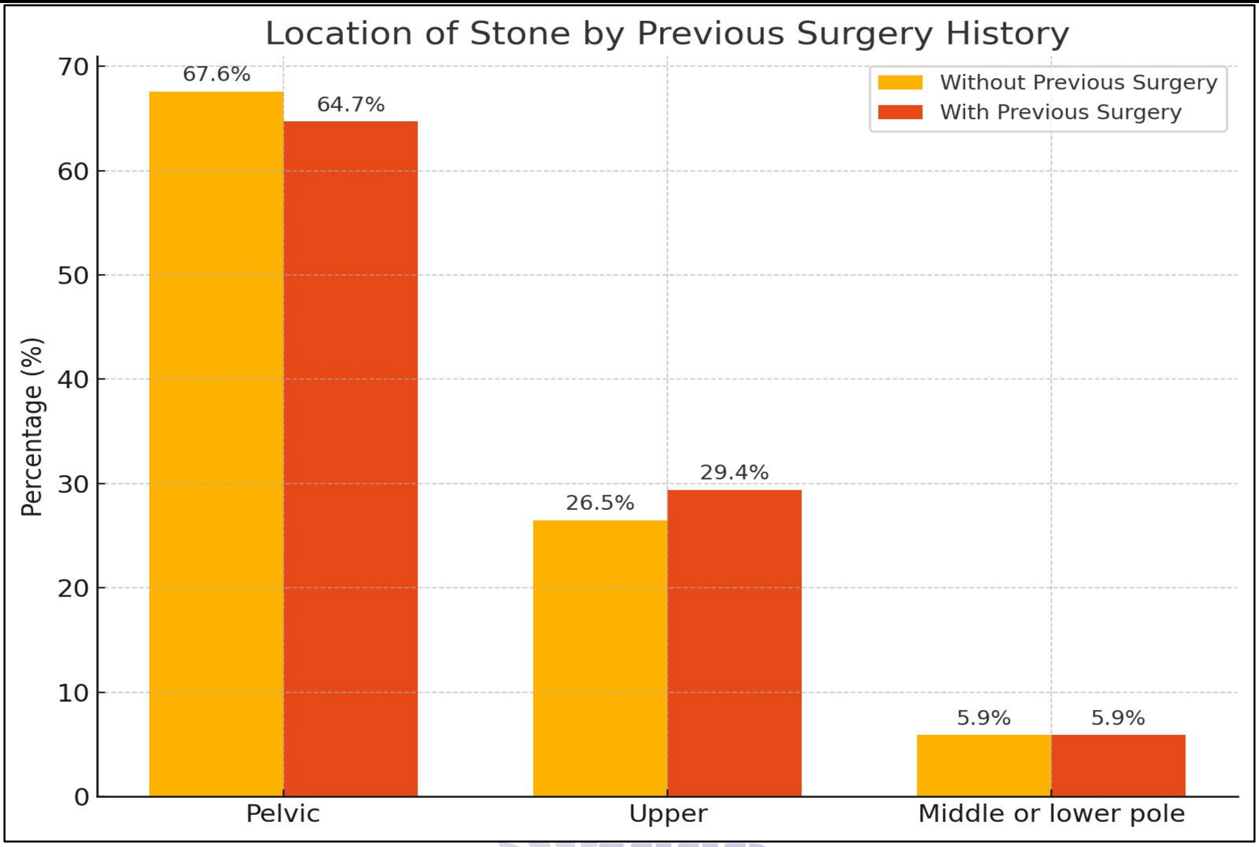

Figure 4

None of the patients in either group required a blood transfusion before surgery (p = 1.000), indicating a stable preoperative hematologic profile (Table 10).

Table 10: Requirement of blood transfusion before surgery among cases for two groups by previous surgery history

	Group			
	Without previous surgery		With previous surgery	
	n	%	n	%
Yes	0	0.0	0	0.0
No	34	100.0	34	100.0
Total	34	100.0	34	100.0

Chi-square = 0.00 P-value = 1.000

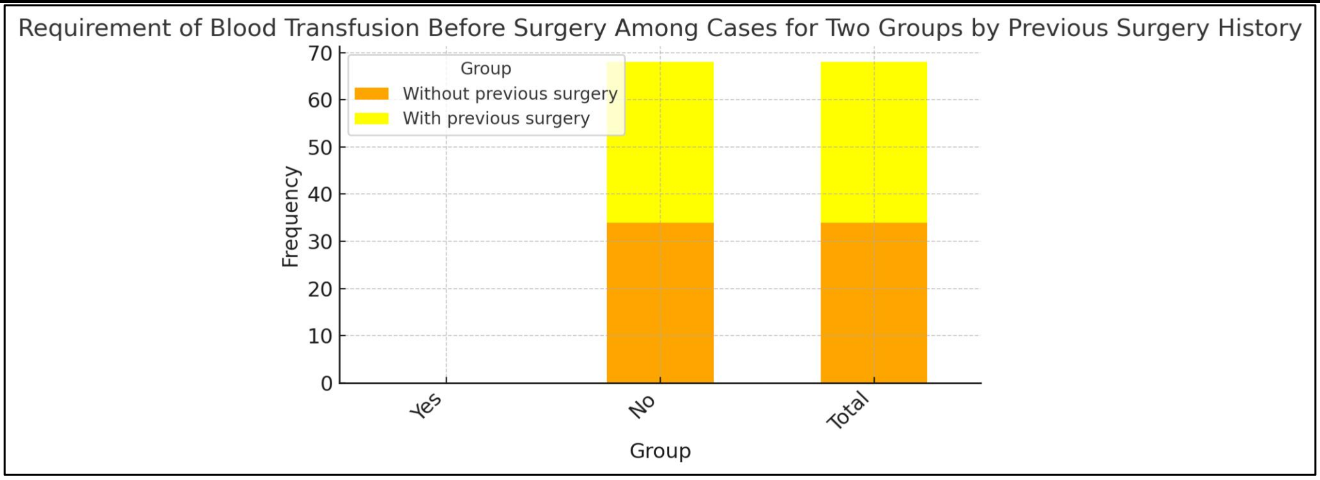

Figure 5

Mean stone sizes were 2.71±0.59 cm (non-surgical group) vs. 2.81±0.49 cm (surgical group), a statistically insignificant difference (p = 0.433). Detailed data are provided in Table 11.

Table 11: Distribution of size of stone for two groups by previous surgery history

Size (cm)	Group		P-value
	Without previous surgery	With previous surgery	
Mean	2.71	2.81	0.433
SD	0.59	0.49	
Median	2.65	2.70	
Q1	2.30	2.50	
Q3	3.00	3.00	

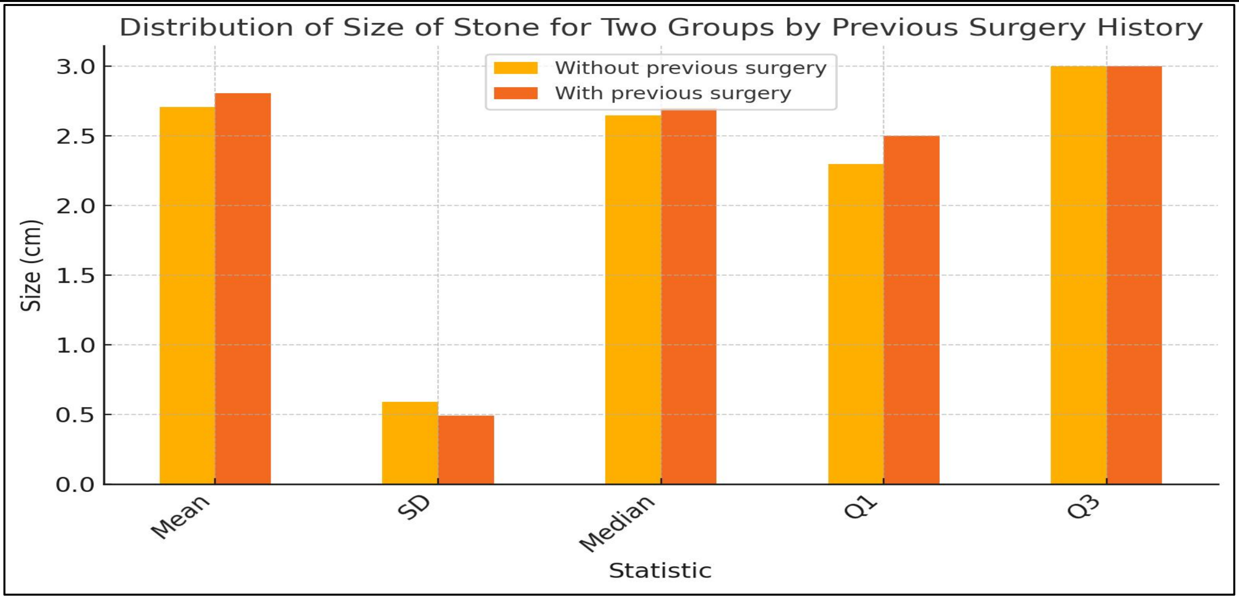

Figure 6

Preoperatively, mean hemoglobin (Hb) levels were 14.5±1.5 g/dl in the non-surgical group vs. 13.8±1.7 g/dl in the surgical group (p = 0.073). Postoperative levels dropped to 14.2±1.5 g/dl and 13.6±1.7 g/dl, respectively (p = 0.137).

Although intra-group reductions in Hb levels were statistically significant (p < 0.001 for both groups), the inter-group difference in Hb drop—0.34±0.21 g/dl (non-surgical) vs. 0.23±0.33 g/dl (surgical)—was not significant (p = 0.265). Refer to Table 12 for hemoglobin trends before and after PCNL.

Table 12: Hemoglobin levels before and after surgery for two groups by previous surgery history

Hemoglobin levels (g/dl)		Group		P-value
		Without previous surgery	With previous surgery	
Before surgery	Mean	14.5	13.8	0.073
	SD	1.5	1.7	
	Median	14.6	14.1	
	Q1	13.5	12.9	
	Q3	15.6	14.7	
After surgery	Mean	14.2	13.6	0.137
	SD	1.5	1.7	
	Median	14.1	14.1	
	Q1	13.1	12.7	
	Q3	15.2	14.6	
P-value		< 0.001	< 0.001	

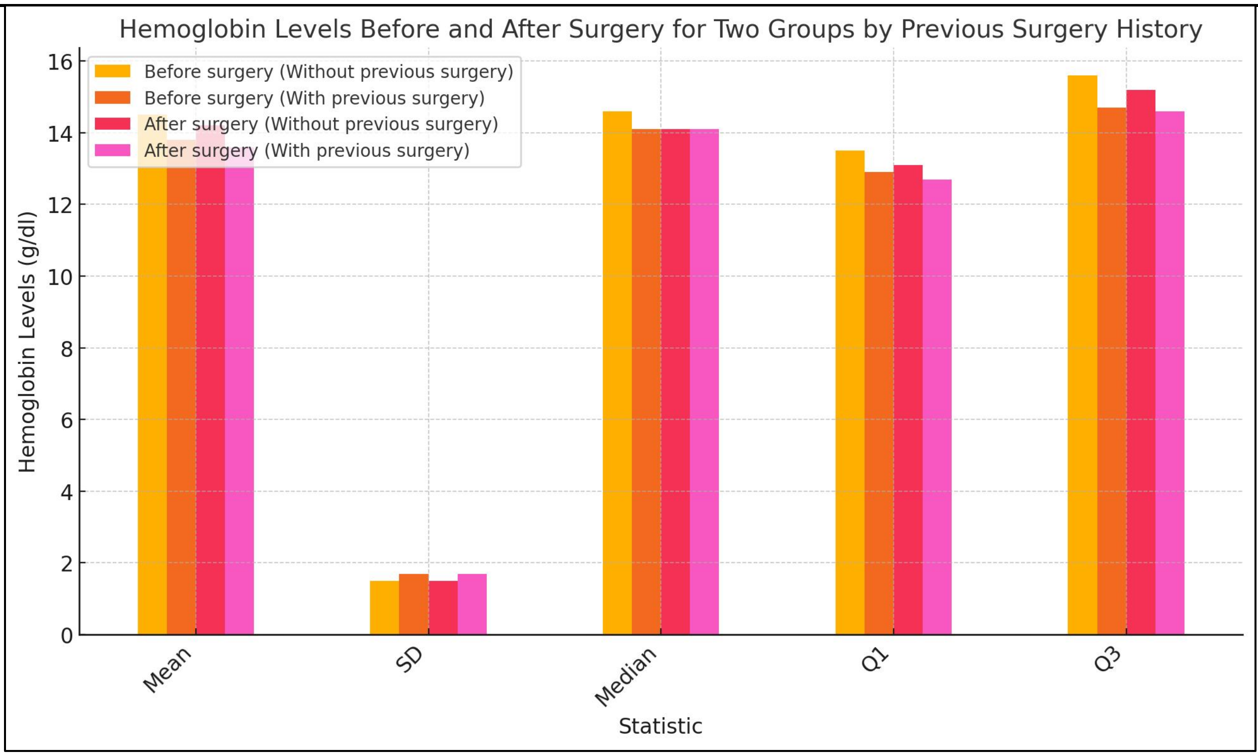

Figure 7

Postoperative blood transfusion was required in 3 patients (8.8%) from the surgical history group, while none in the non-surgical group needed it. Though approaching statistical significance, this difference did not cross the threshold (p = 0.076, Table 13).

Table 13: Requirement of blood transfusion after surgery among cases for two groups by previous surgery history

	Group			
	Without previous surgery		**With previous surgery**	
	n	%	**n**	%
Yes	0	0.0	3	8.8
No	34	100.0	31	91.2
Total	34	100.0	34	100.0

Chi-square = 3.14 P-value = 0.076

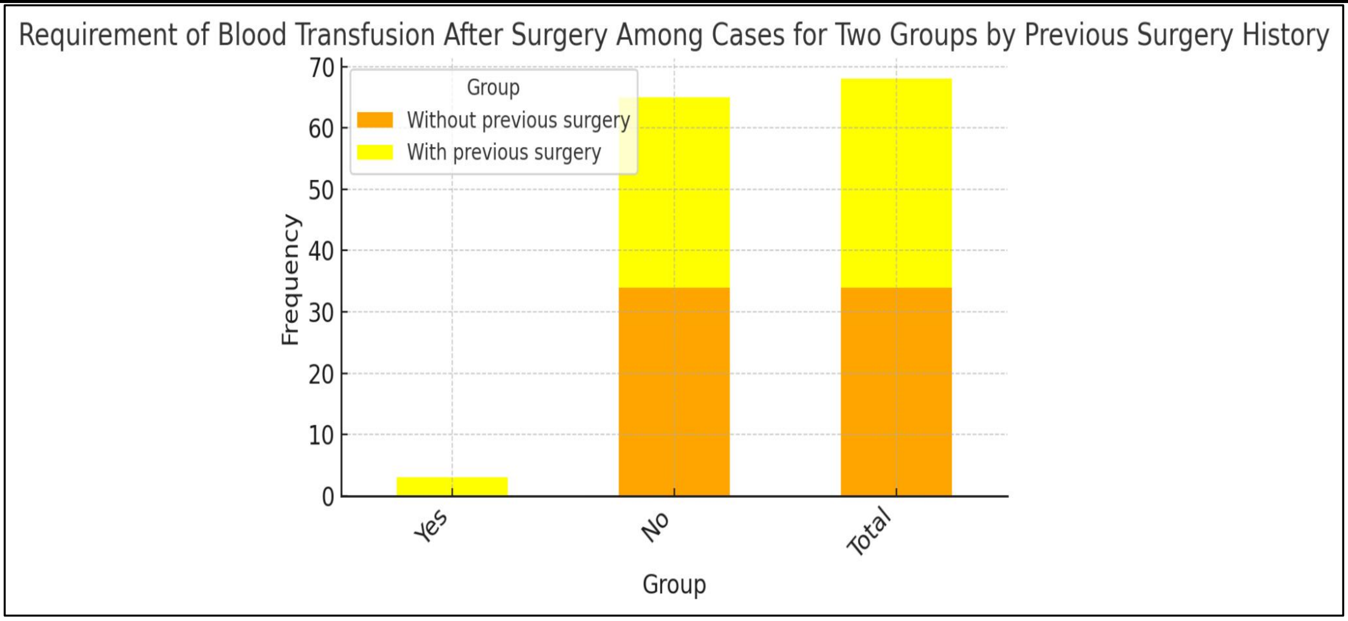

Figure 8

Regarding the number of transfusions, 2 patients required 1 unit, and 1 required 2 units in the surgical group, compared to none in the other group, suggesting a borderline significance (p = 0.055). These results are visually depicted in Figure 9 and documented in Table 14.

Table 14: Number of blood transfusion after surgery among cases for two groups by previous surgery history

	Group			
	Without previous surgery		**With previous surgery**	
	n	%	**n**	%
None	**34**	**100.0**	**31**	**91.2**
1.0	**0**	**0.0**	**2**	**5.9**
2.0	**0**	**0.0**	**1**	**2.9**
Total	**34**	**100.0**	**31**	**91.2**

Likelihood ratio = 3.14 P-value = 0.055

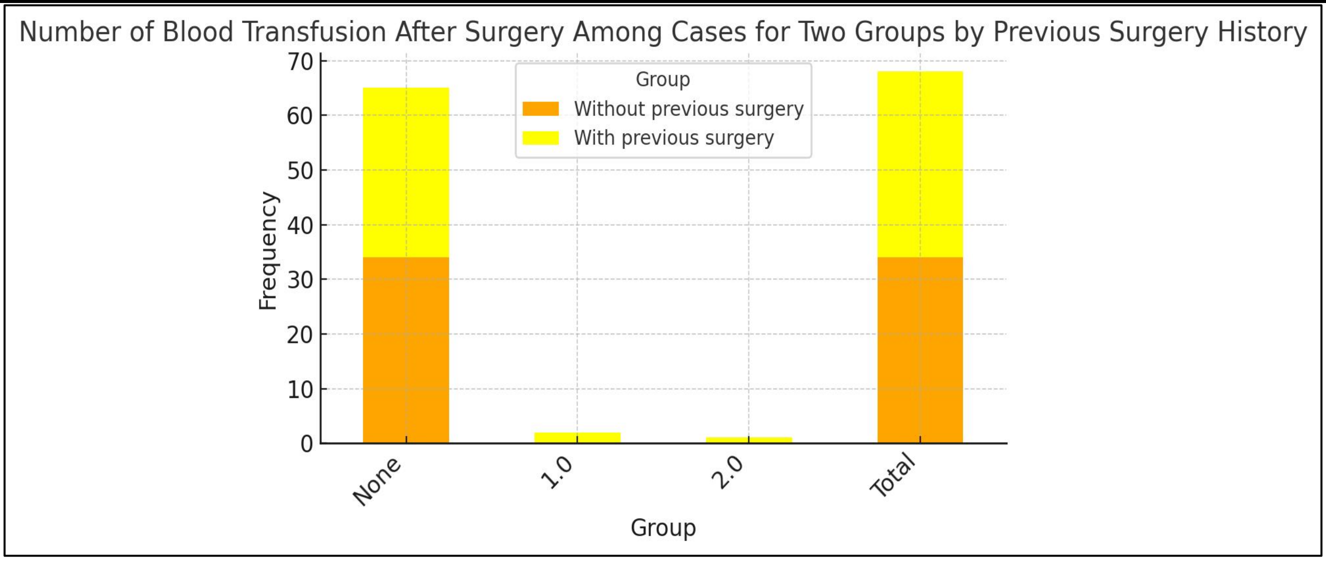

Figure 9

The mean hospital stay was significantly longer in the surgical history group (4.12±1.23 days) compared to the non-surgical group (3.71±0.87 days, p = 0.042). Additionally, 50% of the surgical history group stayed ≥4 days, compared to only 25% in the non-surgical group.

These findings are detailed in Table 15 and graphically represented in Figure 10.

Table 15: Hospital length of stay for two groups by previous surgery history

Duration (days)	Group		P-value
	Without previous surgery	With previous surgery	
Mean	3.71	4.12	0.042
SD	0.87	1.23	
Median	3.00	4.00	
Q1	3.00	3.00	
Q3	4.00	5.00	

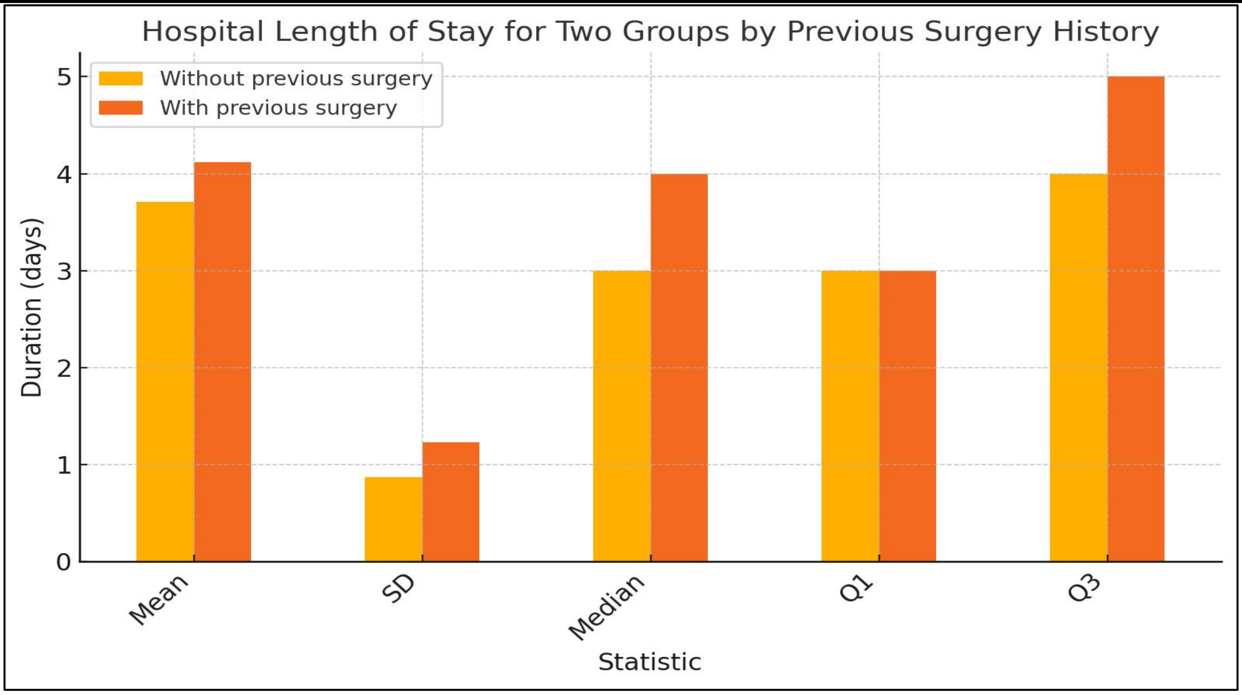

Figure 10

Normality testing using the Shapiro-Wilk test revealed that most variables—age, stone size, and Hb levels (pre- and post-op)—followed a normal distribution ($p > 0.05$). However, hospital LOS showed significant deviation from normality in both groups ($p < 0.001$ and $p = 0.012$, respectively). See Table 16 for detailed statistics.

Table 16: Tests of Normality of data for justification of test applied

	Group	Shapiro-Wilk		
		Statistic	df	Sig.
Age (years)	Without H/o POS	0.964	34	0.315
	With H/o POS	0.952	34	0.142
Size of stone (cm)	Without H/o POS	0.947	34	0.099
	With H/o POS	0.954	34	0.167
Pre-op Hb (g/dl)	Without H/o POS	0.972	34	0.507
	With H/o POS	0.958	34	0.213
Post-op Hb (g/dl)	Without H/o POS	0.966	34	0.362
	With H/o POS	0.953	34	0.154
Length of stay (days)	Without H/o POS	0.767	34	0.000
	With H/o POS	0.915	34	0.012

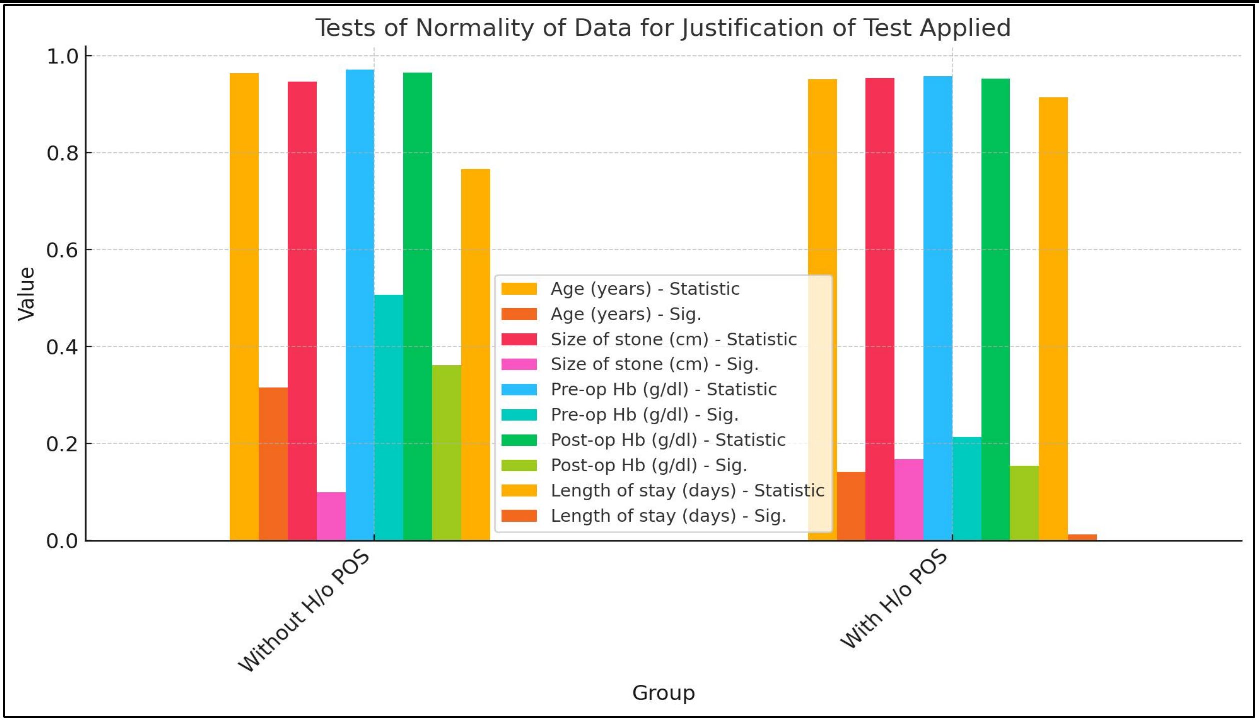

Figure 11

To assess predictors of Hb decrease > 0.4 g/dl, multiple patient factors were analyzed:

- **Age**: Slightly lower risk in younger patients (OR = 0.90; adj. OR = 0.85), but not significant.

Gender: Females showed a higher frequency of Hb decrease (48.4%) compared to males (29.7%), with OR = 2.22 and adjusted OR = 2.40, but again not statistically significant.

Stone size, location, laterality, and POS history were all statistically non-significant predictors.

These findings are compiled in Tables 17a and 17b.

Table 17a Decrease in haemoglobin with respect to group and confounding variables

		Decrease in Hb				Odds Ratio (95.0% CI)	Adj. Odds Ratio (95.0% CI)
		> 0.40		≤ 0.40			
		n	%	n	%		
Age (years)	**> 40.0**	18	37.5	30	62.5	0.90 (0.31 – 2.62)	0.85 (0.26 – 2.75)
	≤ 40.0	08	40.0	12	60.0	Ref	Ref
Gender	**Female**	15	48.4	16	51.6	2.22 (0.82 – 6.00)	2.40 (0.86 – 2.75)
	Male	11	29.7	26	70.3	Ref	Ref
Location	**Other**	08	34.8	15	65.2	0.80 (0.28 – 2.28)	0.97 (0.88 1.07)
	Pelvic	18	40.0	27	60.0	Ref	Ref
Kidney Affected	**Left**	08	32.0	17	68.0	0.65 (0.23 – 1.84)	0.68 (0.23 – 2.2)
	Right	18	41.9	25	58.1	Ref	Ref
Size of stone (cm)	**> 3.0**	04	28.6	10	71.4	0.58 (0.16 – 2.09)	0.47 (0.12 – 1.82)
	≤ 3.0	22	40.7	32	59.3	Ref	Ref

H/o POS	Yes	13	38.2	21	61.8	1.00 (0.38 – 2.66)	1.12 (0.38 – 3.27)
	No	13	38.2	21	61.8	Ref	Ref

Table 17b Comparison of change in haemoglobin with respect to gender, age, kidney affected, location and size of stone

		Decrease in haemoglobin					P-value
		Mean	SD	Median	Q1	Q3	
Age (years)	≤ 40.0	0.30	0.26	0.30	0.20	0.40	0.827
	> 40.0	0.28	0.29	0.30	0.20	0.40	
Gender	Male	0.25	0.29	0.30	0.20	0.40	0.280
	Female	0.33	0.27	0.30	0.10	0.60	
Kidney affected	Right	0.31	0.23	0.30	0.20	0.40	0.466
	Left	0.23	0.35	0.30	0.20	0.40	
Location of stone	Pelvic	0.27	0.30	0.30	0.20	0.40	0.983
	Upper	0.31	0.25	0.30	0.10	0.40	
	Middle or lower pole	0.32	0.19	0.25	0.20	0.45	
Size of stone (cm)	≤ 3.0	0.34	0.19	0.30	0.20	0.40	0.063
	> 3.0	0.09	0.46	0.20	-0.20	0.40	

Average Hb drop comparisons across these variables also confirmed no statistically significant associations, with p-values > 0.05 across age, gender, affected kidney, stone location, and stone size.

DISCUSSION

Percutaneous nephrolithotomy (PCNL) is the gold standard and primary surgical technique for managing kidney stones larger than 20 mm, particularly complex or staghorn stones, and those resistant to other treatment modalities due to infection, hardness, obstruction, or anatomical abnormalities. It offers the highest stone-free rate (SFR) among such patients. However, PCNL is not without complications; these include infection, bleeding, transfusion needs, injury to adjacent organs, residual stones, renal dysfunction, and, rarely, mortality. Blood loss during surgery is among the most concerning complications, with risk factors such as age, stone size, staghorn calculi, multiple access points, preoperative urinary tract infections (UTIs), diabetes mellitus, prolonged surgical time, and stone composition contributing to increased risk.[14,15,16] Previous open renal stone surgery (POS) has been identified as a potential additional risk factor for bleeding during PCNL. Some studies reported higher blood loss and transfusion needs in patients with a history of POS.[17,18] Conversely, other research found no significant differences in intraoperative blood loss between patients with or without a POS history.[19,20,21,22] These mixed findings support the current study's results, which also found no statistically significant difference in intraoperative blood loss between the two groups, aligning with the null hypothesis.

The current study revealed that although both groups experienced a significant drop in hemoglobin (Hb) levels during PCNL, the difference between groups was not statistically significant. These findings support PCNL as a safe procedure for patients regardless of POS history and are consistent with other literature.[23,24,25]

Patient demographics showed statistically significant differences in age between groups, with the group with previous open surgery (POS), Group A, being significantly *older* (mean age 50.0±7.9 years) compared to the group without previous surgery (non-POS), Group B (mean age 41.2±11.3 years; $p < 0.001$).49 However, several studies have reported no age-related differences.[26] Hb reduction in patients ≤40 years and >40 years was not significantly different (0.30 ± 0.26 g/dl vs. 0.28 ± 0.29 g/dl; $p = 0.827$), confirming age had no meaningful effect on bleeding, as previously reported.

Gender distribution was similar between groups ($p = 0.808$), and other studies echoed this finding. Although females had a slightly higher frequency of Hb decrease >0.4 g/dl, this was not statistically significant (OR = 2.22; adjusted OR = 2.40; $p = 0.280$).

There was no significant difference in kidney stone characteristics (size, location, or laterality) between groups. Most stones were located in the renal pelvis, followed by the upper, middle, or lower poles. Mean stone size was 2.71 ± 0.59 cm (non-POS) vs. 2.81 ± 0.49 cm (POS) ($p = 0.433$). Mean Hb reduction was similar across stone laterality, location, and size categories. Stone characteristics were found to be statistically equivalent across groups in line with existing studies.[27,28,29]

Intraoperative parameters, including surgical time, fluoroscopy use, number of access tracts, supracostal access, analgesia needs, and hospital length of stay (LOS), were also similar between groups (all $p > 0.05$).45 The mean drop in Hb was 0.34±0.21 g/dl (non-POS) vs. 0.23±0.33 g/dl (POS) ($p = 0.265$). No patients required preoperative transfusion, but 8.8% in the POS group needed transfusion postoperatively, compared to 0% in the other group ($p = 0.076$).

Some studies, however, reported significant Hb reduction (1.78 g/L), higher bleeding risk requiring angioembolization (RR = 3.73), and lower initial SFR (RR = 0.96) in POS patients.36,37,48 Mean blood loss was also markedly different in these studies (405 cc in POS vs. 103 cc in non-POS; $p < 0.001$). These discrepancies might stem from differences in technique, surgeon experience, or stone characteristics.

Hospital length of stay (LOS) in this study was significantly *longer* in the group with previous open surgery (POS), Group A (mean 4.12±1.23 days), compared to the group without previous surgery (non-POS), Group B (mean 3.71±0.87 days; $p = 0.042$). Overall, LOS, blood transfusions, operative time, complication rates, SFR, and analgesic needs were statistically comparable across groups in several supporting studies.[30,31,32]

CONCLUSION

The findings of the study suggest that Percutaneous Nephrolithotomy (PCNL) stands out as a robust and reliable procedure for managing kidney stones. The evidence suggests its safety and efficacy, particularly concerning intraoperative blood loss, are comparable between patients with no surgical history and those who have undergone previous open surgery (POS). This consistency underscores PCNL's value as a primary treatment modality across diverse patient backgrounds.

However, patients with a history of POS, while not experiencing increased blood loss risk during the procedure itself, appear to face a higher likelihood of prolonged hospitalization compared to their counterparts without prior open surgery. This finding highlights the need for careful patient counseling and resource allocation, acknowledging that while PCNL remains effective for these individuals, their recovery trajectory may be extended, potentially due to factors like adhesions or altered anatomy influencing postoperative recuperation.

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