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Investigation of Factors Associated with Excessive Bleeding in Patients Undergoing Percutaneous Nephrolithotomy Surgery at Imam Khomeini Hospital in Urmia City during the period from October 2019 to October 2020

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Abstract

Introduction

Bleeding during percutaneous nephrolithotomy (PCNL) surgery is a significant concern and a common surgical complication. This study aimed to identify factors associated with excessive bleeding in patients during or after PCNL surgery.

Methods

In this retrospective study, a total of 357 patients who underwent PCNL surgery were evaluated within the period from October 2019 to October 2020. Patient-related factors, kidney stones, and surgical details were recorded. The median drop in hemoglobin after PCNL was 5.1, and values exceeding this were considered as excessive bleeding.

Results

In this study, only 51.2% of patients experienced decreased hemoglobin levels. The average stone size in patients with and without reduced hemoglobin levels was 2.48 cm and 2.41 cm, respectively. The mean duration of surgery in patients with and without a decrease in hemoglobin levels was 58.69 minutes and 55.30 minutes, respectively. The mean access time for patients with and without reduced hemoglobin levels was 68.62 seconds and 65.71 seconds, respectively. The mean exposure time to radiation for patients with and without a decrease in hemoglobin levels was 74.11 seconds and 68.80 seconds, respectively. In this study, no significant relationship was found between patient gender, stone size, duration of surgery, access time, previous surgical history, and a decrease in hemoglobin levels. However, a significant association was observed between the access site and decreased hemoglobin levels.

Conclusion

Despite concerns regarding intraoperative complications, PCNL is an effective and safe treatment modality for patients with kidney stones, irrespective of their clinical treatment history. Furthermore, the advantages of this minimally invasive approach can be applied to all patients.

Keywords: bleeding, kidney stones, percutaneous nephrolithotomy, hemorrhage, risk factors

Introduction

The prevalence of kidney stones in Iran is higher than the global average, estimated to be around 2–3% [2, 1]. Risk factors associated with kidney stone formation include increasing age, male gender, dehydration, and low fluid intake [3]. Treatment options for kidney stones include percutaneous nephrolithotomy (PCNL), retrograde intrarenal surgery (RIRS), and extracorporeal shock wave lithotripsy (ESWL). According to the European Urology Guidelines, ESWL is recommended for stones smaller than 2 cm, while PCNL is preferred for stones larger than 2 cm [4]. PCNL is considered an effective and reliable treatment method, with reported success rates of up to 90% compared to other approaches. However, complications like kidney bleeding are this treatment modality's most common and potentially dangerous adverse events [6, 5]. In the context of PCNL, kidney

bleeding can be attributed to causes such as arterial laceration, pseudoaneurysm, and arteriovenous fistula [7]. Bleeding can occur during needle insertion, dilation of the collecting system, endoscopy procedures, or stone fragmentation, with most cases involving venous bleeding [8]. The common site of significant bleeding in PCNL is associated with segmental arteries, small arcuate vessels, and interlobar vessels [9]. Severe kidney bleeding in approximately 0.8% of patients undergoing PCNL may require surgical interventions such as angioembolization and blood transfusion [9, 10]. Risk factors for bleeding in the context of PCNL include previous kidney surgery due to stones, stone size, degree of kidney swelling (hydronephrosis), prolonged surgical duration, and patient conditions such as diabetes mellitus [11, 12]. Controlling the influential risk factors for severe kidney hemorrhage can reduce the likelihood of bleeding. Despite numerous studies on the various causes of bleeding, except for a few well-established risk factors, there has been a lack of consensus on other collective risk factors. Therefore, in this retrospective study, we analyzed patients who underwent PCNL surgery at Imam Khomeini Hospital in Urmia to identify factors significantly predicting severe kidney hemorrhage.

Method

The current study is a retrospective descriptive-analytical study. Patient records of patients who underwent PCNL surgery by a single surgeon at Imam Khomeini Hospital in Urmia City from October 2019 to October 2021 were extracted. Factors related to the patients (age, gender, weight, history of surgery, history of hypertension, diabetes, renal insufficiency), factors related to the kidney stone (size, density, type [staghorn or non-staghorn], distance from the skin, kidney anomalies, presence of kidney swelling), and factors related to the surgery (time, access site(s), number of accesses, stent placement, nephrostomy tube insertion, blood transfusion) were recorded and examined. Pre- and postoperative test results were also recorded. The difference in hemoglobin levels before and after surgery was considered a measure of bleeding. The median drop in hemoglobin after PCNL was 5.1, and values exceeding this were considered as excessive bleeding. The relationship of this measure with the factors mentioned above was evaluated. The present study was approved by the Ethics Committee of Urmia University of Medical Sciences with the ethics code IR.UMSU.REC.1400.256. After obtaining permission from the ethics committee, data collection was initiated. Throughout the research process, the researchers adhered to the ethical principles stated in the Declaration of Helsinki and the Code of Ethics of the Ministry of Health. Patient information remained confidential, and no costs were imposed on the individuals under investigation.

Statistical Analysis

For categorical variables and examining the distribution of gender and age in two groups with severe bleeding and without severe bleeding, the chi-square test was used. To compare the means of quantitative variables (hemoglobin) between the groups, an independent t-test or Mann-Whitney U test (based on the normality of the data) was employed. To compare the hemoglobin levels before and after surgery, the paired t-test, the Wilcoxon signed-rank test, or their non-parametric equivalent, the Wilcoxon rank-sum test, were used. The changes in hemoglobin between the two groups were analyzed using an independent t-test or Mann-Whitney U test, and in more than three groups, one-way analysis of variance (ANOVA) or its non-parametric equivalent, the Kruskal-Wallis test, was performed. Defining features of the patients were presented using tables, frequency charts, and descriptive statistics such as mean and standard deviation. A significance level of less than 0.05 was considered statistically significant. The obtained data were analyzed using SPSS software version 21.

Results

In this study, a total of 375 patients undergoing PCNL were examined and evaluated. Among them, 192 patients (51.2%) experienced decreased hemoglobin levels after PCNL, including 115 males (59.9%) and the remaining females. On the other hand, 183 patients (48.8%) did not experience a decrease in hemoglobin levels, including 114 males (62.3%) and the remaining females. Statistical analysis did not reveal a significant difference between patient gender and hemoglobin decrease (p-value = 0.63) (Table 1). 126 patients (65.6%) with hemoglobin decrease and 116 patients (63.6%) without hemoglobin decrease had kidney swelling. Statistical analysis did not reveal a significant difference between the presence or absence of kidney swelling and hemoglobin decrease (p-value = 0.65) (Table 1). The mean age in patients with hemoglobin decrease and those without was 46.52 ± 13.06 years and 44.56 ± 16.28 years, respectively. Statistical analysis showed no significant difference in mean age between patients with hemoglobin decrease (p-value = 0.19) (Table 1). The mean body mass index (BMI) in patients with hemoglobin decrease was 27.99 ± 5.28 kg/m², while in patients without hemoglobin decrease, it was 27.96 ± 5.28 kg/m². Statistical analysis did not reveal a significant difference in BMI between patients with hemoglobin decrease (p-value = 0.96) (Table 1).

Stone Size

The mean stone size in patients with a hemoglobin decrease was 2.48 ± 1.28 cm, while in patients without a hemoglobin decrease, it was 2.41 ± 1.19 cm. Statistical analysis did not reveal a significant difference in stone size between patients with hemoglobin decrease (p-value = 0.59) (Table 1).

Surgical Duration

The mean surgical duration in patients with a hemoglobin decrease was 58.69 ± 1.46 minutes, while in patients without a hemoglobin decrease, it was 55.30 ± 1.14 minutes. Statistical analysis showed no significant difference in surgical duration with hemoglobin decrease (p-value = 0.07) (Table 1).

Access Time

The mean access time in patients with a hemoglobin decrease was 68.62 ± 4.88 seconds, while in patients without a hemoglobin decrease, it was 65.71 ± 4.70 seconds. Statistical analysis did not reveal a significant difference in access time with hemoglobin decrease (p-value = 0.67) (Table 1).

Variable		Group with low hemoglobin	Group without low hemoglobin	P-value
Sex	Male	59.9%	62.3%	0.63
	Female	40.1%	37.7%	
Hydronephrosis	Positive	65.6%	63.4%	0.65
	Negative	34.4%	36.6%	
Age (year)		46.52±13.06	44.56±16.28	0.19
BMI		27.99±5.83	27.96±5.28	0.96
Stone size (CM)		2.48±1.28	2.41±1.19	0.59
Surgery time (Minute)		58.69±1.46	55.30±1.14	0.07
Assess duration (seconds)		68.62±4.88	65.71±4.7	0.67
Radiation duration(seconds)		74.11±3.96	68.80±4.12	0.35
Access location	Upper	3%	6%	0.03
	Middle	13%	4.9%	
	Lower	79.4%	85.2%	
	Upper + lower	4.1%	3.3%	
	Middle + bottom	0.5%	0.5%	
History of surgery	Not record	18.8%	58.5%	0.12
	ESWL	27.1%	36%	
	Nephrolithotomy	7.8%	6.6%	
	PCNL	18.8%	15.3%	
PCNL result	Success	87%	89.6%	0.42
	Failure	13%	10.4%	
History of surgery in patients with successful PCNL	Not record	47.9%	59.1%	1
	ESWL	26.3%	20.1%	0.51
	Nephrolithotomy	7.2%	6.1%	1
	PCNL	18.6%	14.6%	1

Table 1: Comparison of frequency distribution of gender, hydronephrosis, location of access, previous history of surgery, success rate of PCNL and history of surgery in successful PCNL and comparison of mean and deviation of age, body mass index, stone size criterion, surgical time, access time and duration Radiation in patients with and without hemoglobin drop

Duration of Radiation Exposure

The duration of radiation exposure in patients with a hemoglobin decrease was 74.11 ± 3.96 seconds, while in patients without a hemoglobin decrease, it was 68.4 ± 80.12 seconds. Statistical analysis did not reveal a significant difference in the duration of radiation exposure with hemoglobin decrease (p-value = 0.35) (Table 1).

Access Site

Among the 192 patients with hemoglobin decrease, the access site was in the superior calyx for 6 patients (3%), in the middle calyx for 25 patients (13%), in the inferior calyx for 152 patients (79.4%), in both the superior and inferior calyx for 8 patients (4.1%), and in the middle and inferior calyx for one patient (0.5%). Among the 183 patients without hemoglobin decrease, the access site was in the superior calyx for 11 patients (6%), in the middle calyx for 9 patients (9.4%), in the inferior calyx for 156 patients (85.2%), in both the superior and inferior calyx for 6 patients (3.3%), and in the middle and inferior calyx for one patient (0.5%). Statistical analysis revealed a significant difference between the access site and bleeding during percutaneous nephrolithotomy surgery (p-value = 0.03) (Table 1).

Previous Surgical History

Based on the analysis of previous surgical history in patients, it was determined that among the 192 patients with hemoglobin decrease, 89 patients (46.4%) had no previous surgery, 52 patients (27.1%) had a history of ESWL, 15 patients (7.8%) had a history of nephrolithotomy, and 36 patients (18.8%) had a history of PCNL. Among the 183 patients without hemoglobin decrease, 107 patients (58.5%) had no previous surgery, 36 patients (19.7%) had a history of ESWL, 12 patients (6.6%) had a history of nephrolithotomy, and 28 patients (15.3%) had a history of PCNL. According to this analysis, no significant difference was found in the type of surgical history between patients with hemoglobin decrease and those without (p-value = 0.12) (Table 1).

Success Rate

Among the 192 patients with a hemoglobin decrease, surgery was successful in 167 patients (87%), and among the 183 patients without a hemoglobin decrease, surgery was successful in 164 patients (89.6%). There was no significant difference

in surgical success and hemoglobin decrease (p-value = 0.42) (Table 1). Among the 167 cases of successful surgery, 80 patients (47.9%) had no previous surgery, 44 patients (26.3%) had a history of ESWL, 12 patients (7.2%) had a history of nephrolithotomy, and 31 patients (18.6%) had a history of PCNL. Among the 164 patients with successful surgery, 97 patients (59.1%) had no previous surgery, 33 patients (20.1%) had a history of ESWL, 10 patients (6.1%) had a history of nephrolithotomy, and 24 patients (14.6%) had a history of PCNL. Based on this, there was no significant difference in the type of surgery and hemoglobin decrease in successful surgeries (p-value = 0.52) (Table 1).

Hemoglobin levels between pre-admission and intraoperative stages

The mean difference in hemoglobin levels between pre-admission and intraoperative stages in male patients was -2.20 ± 0.91g/dL; in female patients, it was -2.06 ± 0.77g/dL. There was no significant difference between the patient's gender and the difference in hemoglobin levels between pre-admission and intraoperative stages (p-value = 0.25) (Table 2). The mean difference in hemoglobin levels between pre-admission and three days post-operation in male patients was -2.39 ± 0.11 mg/dL; in female patients, it was 2.13 ± 0.98 mg/dL. There was no significant difference between the patient's gender and the difference in hemoglobin levels between pre-admission and three days post-operation (p-value = 0.13) (Table 2). The mean difference in hemoglobin levels between pre-admission and intraoperative stages in patients with hemoglobin decrease below 45 years of age was -2.16 ± 0.06 mg/dL. In patients over 45, it was -2.12 ± 0.11 mg/dL. There was no significant difference between the patients' age groups (below and above 45 years) and the difference in hemoglobin levels between pre-admission and intraoperative stages (p-value = 0.74) (Table 2). The mean difference in hemoglobin levels between pre-admission and three days post-operation in patients with hemoglobin decrease below 45 years of age was -2.0 ± 18.10 mg/dL. In patients above 45 years of age, it was -2.42 ± 0.13 mg/dL. There was no significant difference between the patients' age groups (below and above 45 years) and the difference in hemoglobin levels between pre-admission and three days post-operation (p-value = 0.13) (Table 2). The mean decrease in hemoglobin levels during the operation compared to pre-admission, based on the location of the stone, is presented in Table 3. Statistical analyses did not show a significant difference between the stone location and the decrease in hemoglobin levels (p-value = 0.21) (Table 3).

Variable		During operation with admission	Three days after the operation with beginning of admission
Sex	Male	-2.20±0.91	-2.39±0.11
	Female	-2.06±0.77	-2.13±0.98
P-value		0.25	0.13
Age distribution	Less than 45 years	-2.16±0.06	-2.18±0.10
	More than 45 years	-2.12±0.11	-2.42±0.13
P-value		0.74	0.13

Table 2: Average hemoglobin drop during surgery and three days after surgery according to gender and age group

Stone location	Mean ± standard deviation	P-value
Pelvis + ureter	-.156±0.46	0.49
Upper calyx + pelvis	-2.27±0.82	
Pelvis	-.2.33±1.22	
Lower calyx	-1.93±0.77	
Staghorn	-.2.79±1.23	
Lower calyx + pelvis	-2.15±1.1	
Middle calyx + pelvis	-2.5±1.7	
Middle and lower calyx	-2.6±0.79	
Ureter	-.2.18±0.67	
Lower and upper calyx + pelvis	-2.2±2.2	
Lower and upper calyx	-1.36±0.75	
Middle calyx	-2.5±0.85	
Lower calyx + ureter	-2.35±0.07	
Upper calyx	-2.2±0.87	
Middle and lower calyx + pelvis	-1.25±1.06	

Table 3: The average drop in hemoglobin on the third day after surgery compared to no admission based on stone location

Discussion

Among patients with a decrease in hemoglobin levels, there was no significant difference in gender. Specifically, 50.2% of males and 52.7% of females experienced severe bleeding. Similar to our findings, Meng et al. also observed no association between gender and bleeding, therefore not considering gender as a risk factor for bleeding in PCNL in their study [13].

Our study observed intraoperative hemoglobin levels below 51.2%, and 5.9% of the patients required a blood transfusion. However, there was no significant difference in terms of received packed red blood cells between the two groups (with and without a decrease in hemoglobin levels), as 95.2% of our study population received one unit of packed red blood cells, and one patient (4.8%) received three units of packed red blood cells.

In the studies conducted by Reddy et al., Patterson et al., Jones et al., and El-Kenawy et al., the reported incidence of severe bleeding and the need for blood transfusion in PCNL ranged from 3% to 12% [14–17]. These findings are consistent with the results of our study, where 5.9% of patients required a blood transfusion. In the study by Gullani et al., the blood transfusion rate was 8% in the open surgery group, 5% in the non-surgical group, and 6% in the PCNL group. They did not report a significant relationship between blood transfusion and the type of surgery based on statistical analyses [18]. These findings align with our results, indicating a blood transfusion rate of less than 10%.

During their evaluation of complications arising from PCNL, Darabi et al. reported bleeding in 41% of patients, residual stone in 20.5%, positive SIRS in 20.5%, urine leakage in 15.3%, pain in 12.8%, blood transfusion in 2.5%, and colonic perforation in 2.5% [19]. In the present study, similar observations were made, albeit with a lower percentage of patients experiencing these complications. In the study by Stoller et al., potential factors influencing blood loss in PCNL treatment were reported to be multiple punctures or perforations of the renal pelvis. They also stated that factors such as the location of the puncture, type of vascular dilation, high blood pressure, renal insufficiency, infection, and a history of open nephrolithotomy or extracorporeal shock wave lithotripsy (ESWL) with stone fragmentation did not have an impact on the amount of blood loss [20]. This finding contradicts our study results, which indicate that a history of surgical procedures does not significantly affect blood loss, while the location of the puncture does. According to our evaluation, there was no significant difference between kidney swelling and intraoperative bleeding. Our findings are consistent with the results of the studies conducted by Kocherzhenko et al. and Akman et al., which reported that kidney swelling has no impact on bleeding during PCNL [21, 22].

In contrast, Lee et al. and Snookak et al. found that the absence of kidney swelling is a significant risk factor for bleeding during PCNL [23, 24]. Kim et al. reported that patients without kidney swelling required more prolonged surgical procedures, extended hospital stays, and a higher blood transfusion volume than patients with kidney swelling [25]. Our study showed no significant difference between body mass index (BMI), stone size, radiation dose, and access in patients with intraoperative bleeding. However, the location of the stone had a significant relationship with intraoperative bleeding. Cassaris et al. reported that the factors influencing renal bleeding are unpredictable [26]. Gramos et al. found no association between variables such as age, gender, stone size, and operation time with renal bleeding [27]. Additionally, Kim et al. found no significant relationship between initial patient characteristics, such as age, gender, and BMI, in patients undergoing PCNL with those undergoing embolization and angiomyolipoma [28]. These results are consistent with our study's findings.

Our study showed no significant difference between hemoglobin drop and surgical history. Gupta et al. demonstrated that surgical history does not alter the outcomes of PCNL. However, due to previous surgeries and anatomical changes in the kidney, the number of access points to renal stones during PCNL increases [29]. Sofikrim et al. did not observe a significant difference between the duration of surgery and intraoperative complications with the success rate of the surgery. In this study, the efficacy and success of PCNL were comparable among different groups [30]. These findings are consistent with our study results, as we also found no significant difference in surgical success among patients with a drop in hemoglobin.

Mongan et al. investigated patients with a previous extracorporeal shock wave lithotripsy (ESWL) history and underwent PCNL. They divided the patients into four groups based on the time interval between ESWL and PCNL: one, two, three, and more than three months. Their examinations found no statistically significant difference among these groups regarding residual kidney stones and blood transfusions. They concluded that with imaging techniques, improved quality of instruments, technological advancements, and increased surgical experience, excellent success rates in lithotripsy and reduced blood transfusion could be achieved [31]. Our study results demonstrated no significant relationship between different surgical histories and a drop in hemoglobin. In the study by Resorlu et al., the duration of surgery, access method, fluoroscopy, nephrostomy tube removal, and length of hospital stay were examined, and no statistically significant differences were observed among these variables in patients. They demonstrated that PCNL could be safely performed in patients with a history of open nephrolithotomy and ESWL using standard techniques. These patients did not report a higher risk of complications, and their surgical success was comparable to patients without prior surgeries [32]. Margul et al. showed that the surgical success rate in the group with a history of open kidney surgery was lower compared to other groups with different surgical histories. They also demonstrated no significant relationship between intraoperative and postoperative complications [33]. In our study, the length of hospital stays and surgery duration did not significantly impact patients' intraoperative bleeding or the absence of bleeding. The findings of our study demonstrated that the demographic

characteristics of patients had no significant impact on the decrease in hemoglobin levels during PCNL. However, the location of the stone was identified as an essential factor influencing the decline in hemoglobin levels during PCNL. Additionally, in patients with a history of kidney stone interventions, it is expected that the extent of tissue changes and renal anatomy will increase the magnitude of hemoglobin decrease and surgical complications.

Conclusion

Despite concerns regarding intraoperative complications, PCNL remains an effective and safe treatment option for patients with kidney stones, regardless of their clinical treatment history related to kidney stones. Furthermore, the benefits of this minimally invasive approach can be extended to all eligible patients.

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