ORIGINAL RESEARCH

Comparative Analysis of Blood Loss and Transfusion Requirements Among Patients with Staghorn Calculus Undergoing Percutaneous Nephrolithotomy versus Open Stone Surgery in National Kidney and Transplant Institute: 2018-2019

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Objective: Percutaneous nephrolithotomy (PCNL) is the standard of care for the treatment of renal stones >2cm and staghorn calculi. This minimally invasive procedure however has intraoperative hemorrhage as one of its most dreaded complications.
Objective: To analyze the rate of hemorrhage and transfusion requirements among patients undergoing either PCNL or open stone surgery (OSS).
Methods: This was a retrospective study conducted at the National Kidney and Transplant Institute Medical Records Department. Data were collected for the period of January 2018 to December 2019.
Results: One hundred forty cases were included, 102 patients in the PCNL group and 38 in the OSS. The mean age 50.84±11.89 vs. 50.50±10.09 with male to female ratio of 1.2:1 for PCNL and open surgery, respectively. The most common comorbidity was hypertension (89, 63.6%). As regards stone size, majority had >4 cm stone size (61; 43.9%). In PCNL, there was no significant change noted in the hemoglobin (14.69±13.3 vs 12.03±1.91, p= 0.099) as compared to OSS, where there was significant decline (12.77±2.64 vs. 11.06±2.52; = .000. The number of packed red cell units for transfusion was also significantly higher in OSS compared to PCNL group (.526±.861 vs. 159±.502, p .020.)
Conclusion: In the treatment of staghorn calculi, PCNL incurs less blood loss and lower transfusion requirements compared to open stone surgery.

Key words: Open stone surgery, percutaneous nephrolithotomy, staghorn renal calculi, blood transfusion, hemorrhage

Introduction

Kidney stone disease is one of the most common urologic conditions, with a lifetime prevalence of 1-15%, that varies according to age, gender, race and geographic location.[1] It is seen more predominantly among men between ages 40-60 years old. Among races, Causasian Americans have the highest incidence of stone disease followed by Hispanics and Asians.

Staghorn calculi are branched renal stones that occupy the renal pelvis and the renal calyces. Most of these were traditionally treated with open stone surgery (OSS). However, since its introduction in 1976 by Fernstrom and Johannson, percutaneous nephrolithotomy (PCNL) gradually replaced traditional open stone surgery and has emerged as the new standard treatment for renal stones >2cm.[1] The advantages of PCNL over OSS are: minimal bodily and renal trauma, less postoperative

pain, shorter convalescence and a better cosmetic outcome.

The success of PCNL however, is affected by the following factors: patient renal function and co-morbidity, and stone features: number, density, presence of obstructive hydronephrosis, and stone complexity based on Guy Stone Score. Bleeding may also occur during PCNL, which could range from minimal blood loss requiring no transfusion, moderate hemorrhage requiring blood transfusions, to a severe hemorrhage leading to life-threatening hypovolemic shock.

The main indications for OSS are: complex stone burden, treatment failures with less invasive modalities, anatomical anomalies and comorbid conditions. In a developing country like the Philippines, open stone surgery persists as the preferred method of treatment in areas where there is shortage of technological equipment or the lack of expertise in endoscopic stone management. Due to its more invasive nature, it may potentially lead to higher blood loss compared to PCNL.

Intraoperative hemorrhage is therefore one of the most frequent and disturbing complications in both PCNL and open stone surgery. It may occur intraoperatively, in the immediate or late post-operative period.[2] The pathogenesis is renal parenchymal trauma with resultant injury to the intrarenal branches of the renal vasculature. In OSS, it may arise from the renal parenchymal injury or inadvertent laceration of the pyelic vessels during the dissection of the space of Gil-Vernet. In PCNL, this may occur during the percutaneous renal access and renal tract dilation. If significant blood loss is noted, the need to replace blood products becomes expedient and source control should be immediately initiated.

Various studies compared the rate of hemorrhage between OSS and PCNL. Several factors were considered contributory to blood loss during surgery. According to Turna, et al. staghorn calculi, multiple tracts, diabetes, and large stones were associated with increased renal hemorrhage during PCNL. They reported an 8.7% rate of decrease in hematocrit and 23.8% had blood transfusion.[3] A study by Stephene R, et al.[4] on PCNL reveals 3.8% of patients required blood transfusion. Earlier study like from that of Al-kohlany, et al.[9] in 2005, reported blood transfusion were required in 33% cases in OSS and 14% cases in PCNL group.[5] In a study by Falahatkar S, et al., 13.9% of patients required blood transfusion in the PCNL group and 18.8% in the OSS. They concluded no significant difference between PCNL and OSS.[6]

Another study by Kumar, et al.[7] also reported no significant difference between open stone surgery and PCNL in blood transfusion rate. This can be explained by small number of patients included in the study, were chronic renal disease patients and limited number of puncture sites. In 2017, Ali, et al. cited that various risk factors were considered in the transfusion group in his study. These include lesser degree of hydronephrosis, lower preoperative hematocrit, bigger stones, and longer operative time. He reported 10.5% rate of blood transfusion out of 341 subjects.

In a metanalysis done by Chen, et al. PCNL had significantly lower blood loss and transfusion requirements compared to OSS.[9] This is consistent with the study of Ismail, et al. on 208 patients who underwent open OSS and PCNL. Those who underwent PCNL had a lesser incidence of blood loss and blood transfusion rate compared to those in OSS group. As quoted, open technique for the management of complex multiple and staghorn renal stones is still a viable option that should be considered in treating patients with such conditions, especially regarding the cost benefit in the face of limited resources in developing countries. A retrospective study by Ketsuwan, et al.[11] focusing on PCNL, blood transfusion rate was at 9.2% and this is related to large stone size, longer operative time, and multiple tract puncture.

The National Kidney and Transplant Institute is a high volume center in the endoscopic management of urolithiasis. Understanding the potential risk for hemorrhage and transfusion needs of patients undergoing PCNL is important to be able to take the necessary precautions to address this potentially life-threatening complication. The authors therefore compared the intraoperative blood loss and transfusion requirements of PCNL and compared it to OSS among patients with staghorn calculi.

The main objective of the study was to compare the blood loss and transfusion requirements of patients undergoing PCNL vs. OSS for staghorn

calculi. Other specific objectives were to describe the demographics of patients with staghorn calculus, to compare laboratory parameters specifically WBC, platelet, hemoglobin and hematocrit levels of patients, mean blood loss and blood transfusion rates between the two groups.

Methods

This is a retrospective study on adult patients who underwent PCNL and OSS for staghorn calculus from January 2018 up to December 2019 at the National Kidney and Transplant Institute. Patients' privacy was protected by using only the hospital number during review and the data collected were saved in a folder protected with unique codes which was accessible exclusively through the researcher.

Chart review was done on all patients who underwent PCNL and OSS from January 2018 to December 2019. Sampling was via consecutive cases done through the two-year study period. Each chart was reviewed according to the demographics and variables needed. Stone sizes were taken from the official CT KUB done to the patient. Known comorbidities of the patients were included as per patient's past medical history. Patients who are on dialysis, both peritoneal and hemodialysis were still included, as long as they fall according to the criteria. Both baseline and post-surgical laboratory results were also collated and compared. Blood loss and blood transfusion rates were the core complications being considered, and other complications were not collected due to the limitation of the study objectives. Other variables were meticulously reviewed.

Results were expressed as mean and median values and percentages were calculated to describe the numerals of each category. t-test for Independent and Dependent samples, Pearson's Chi-square or Fisher's exact test were used where applicable. A p-value less than 0.05 was considered statistically significant highlight

This was approved by the Institute's Research Ethics Committee (REC). This study was conducted in accordance with ICH-GCP guidelines and regulations and commenced upon approval of the NKTI-REC. Data were collected in the Medical Records Section for the period of January 2018-December 2019.

Results

Table 1 shows the demographic profile of patients with staghorn calculus admitted at the National Kidney Transplant Institute. In the study, the highest mean age was noted among patients under PCNL group while a much lower mean age was seen in patients under the OSS group although no statistical difference was observed between them (50.84±11.89 vs. 50.50±10.09, p .190 > .05).

Male patients comprised 55.7% (78) where 57 (40.7%) were under the PCNL group. Female patients was only 44.3% (62) where the majority was still under the PCNL group (p .100 > .05). In the study, the highest number of patients was married (127; 90.7%) where 92 (65.7%) of them were under the PCNL group. This was followed by 8 (5.7%) patients who were single. Of these, 6 (4.3%) were under the PCNL group. Only 5 (3.6%) patients were widowed/er. In this group, 4 (2.9%) were under the PCNL group (p .924 > .05). Among the comorbidities observed in patients with staghorn calculus, the most common was hypertension (89; 63.6%) where 64 (45.7%) were under the PCNL group (p.560 > .05).

Only 23 (16.4%) patients have diabetes. Of these, 17 (12.1%) patients were under the PCNL group (p 1.000 > .05). There were 2 (1.4%) patients who were undergoing dialysis where all of them had undergone OSS (p .072 > .05). With stone size, the highest number of patients had more than 4 cm stone size (61; 43.9%). There were 41 (29.5%) patients who had 2.1 to 4 cm stone size. In this group, 21 (15.1%) patients had undergone PCNL. Lastly, only 30 (21.6%) patients had stone size of around 2 cm. Of these, 16 (11.5%) had undergone OSS (p .002 < .05).

Table 2.1 shows the significant difference between initial and final laboratory results of patients who underwent PCNL. There was a significant difference between the initial and final white blood cell level after undergoing PCNL (8.57±2.99 vs. 14.50±5.12, p .000 < .05). With

Table 1. Demographics of patients with staghorn calculus, National Kidney and Transplant Institute.

Characteristics	PCNL	Open Stone	Total	p
Age				.190[1]
Mean±SD	50.84±11.89	50.50±10.09	50.75±11.40	
Sex				.100[4]
Male	57 (40.7)	21 (15)	78 (55.7)	
Female	45 (32.1)	17 (12.1)	62 (44.3)	
Civil Status				.924[3]
Single	6 (4.3)	2 (1.4)	8 (5.7)	
Married	92 (65.7)	35 (25)	127 (90.7)	
Widowed/er	4 (2.9)	1 (.7)	5 (3.6)	
Co-Morbidities				
Hypertension	64 (45.7)	25 (17.9)	89 (63.6)	.560[4]
Diabetes Mellitus	17 (12.1)	6 (4.3)	23 (16.4)	1.000[4]
Nephrologic Data				
Dialysis	0 (0)	2 (1.4)	2 (1.4)	.072[4]
Stone Size				.000[3]
2 cm	14 (10.1)	16 (11.5)	30 (21.6)	
2.1 to 4 cm	27 (15.1)	22 (14.4)	49 (29.5)	
> 4 cm	61 (43.9)	0 (0)	61 (43.9)	
Operative Time				.002[1]
Mean±SD	102.17±54.25	160.31±87.23	117.95±69.5	

Note: The results are expressed as Mean±SD unless otherwise shown. Statistical significance is set at $p < .05$. statistical Treatment Used: [1] t-test for Independent Samples; [2] t-test for Dependent Samples; [3] Chi Square test; [4] Fisher Exact test; Abbreviations: Percutaneous Nephrolithotomy (PCNL); White Blood Cell (WBC)

Table 2.1. Laboratory profile of patients with staghorn calculus under PCNL, National Kidney and Transplant Institute.

Characteristics	Initial	Final	p
WBC			.000[2]
Mean±SD	8.57±2.99	14.50±5.12	
Platelets			.026[2]
Mean±SD	288.6±88.57	278.8±216.1	
Hematocrit			.284[2]
Mean±SD	40.24±4.70	39.79±34.05	
Hemoglobin			.099[2]
Mean±SD	14.69±13.3	12.03±1.91	

Note: The results are expressed as Mean±SD unless otherwise shown. Statistical significance is set at $p < .05$. statistical Treatment Used: [1] t-test for Independent Samples; [2] t-test for Dependent Samples; [3] Chi Square test; [4] Fisher Exact test; Abbreviations: Percutaneous Nephrolithotomy (PCNL); White Blood Cell (WBC)

regard to the platelet level of patients under the PCNL group, a slightly higher mean average was noted prior to undergoing procedure (288.6±88.57) compared after PCNL (278.8±216.1, p .026 < .05). Similar observation was also found on the hematocrit level of patients under PCNL group where the initial level was higher compared to the average level after undergoing PCNL (40.24±4.70 vs. 39.79±34.05), no statistical difference was observed (p .284 > .05). Moreover, similar observation was observed to the hemoglobin level of patients under the PCNL group. The initial level of hemoglobin was higher (14.69±13.3) compared to the final hemoglobin level after undergoing PCNL (12.03±1.91). The data however stated no significant difference under the PCNL group (p .099 > .05)

Table 2.2 shows the laboratory profile of patients with staghorn calculus who had undergone OSS. There was a marked increase on the white blood cell count (9.83±2.54 vs. 467.89±2632.65, p .169 > .05). With regard to the platelet level, a higher initial platelet value (286.7±76.23) was observed and this was found to decrease after patients had undergone OSS (252.1±77.1, p .000 < .05). Similarly, the initial hematocrit level was higher and this significantly decreased after undergoing OSS(38.27±7.66 vs. 34.43±6.32; p .000 < .05). Lastly, initial hemoglobin level was higher and this, decreased significantly after patients had undergone OSS (12.77±2.64 vs. 11.06±2.52; p .000 < .05).

Table 3 shows the significant difference between blood loss and number of blood bags used on

Table 2.2. Laboratory profile of patients with staghorn calculus under open stone surgery, National Kidney and Transplant Institute.

Characteristics	Initial	Final	p
WBC Mean±SD	9.83±2.54	467.89±2632.65	.169[2]
Platelets Mean±SD	286.7±76.23	252.1±77.1	.000[2]
Hematocrit Mean±SD	38.27±7.66	34.43±6.32	.000[2]
Hemoglobin Mean±SD	12.77±2.64	11.06±2.52	.000[2]

Note: The results are expressed as Mean±SD unless otherwise shown. Statistical significance is set at p < .05. statistical Treatment Used: [1] t-test for Independent Samples; [2] t-test for Dependent Samples; [3] Chi Square test; [4] Fisher Exact test; Abbreviations: Percutaneous Nephrolithotomy (PCNL); White Blood Cell (WBC)

Table 3. Significant difference between blood loss and number of blood bags transfused on patients with staghorn calculus under PCNL and open stone surgery, National Kidney and Transplant Institute.

Characteristics	PCNL	Open Stone	Total	p
Blood Loss Mean±SD	267.6±258.6	346.05±410.56	288.9±307.7	.020[1]
Number of Bags Mean±SD	.159±.502	.526±.861	.257±.638	.000[1]

Note: The results are expressed as Mean±SD unless otherwise shown. Statistical significance is set at p < .05. statistical Treatment Used: [1] t-test for Independent Samples; [2] t-test for Dependent Samples; [3] Chi Square test; [4] Fisher Exact test; Abbreviations: Percutaneous Nephrolithotomy (PCNL); White Blood Cell (WBC)

patients with staghorn calculus who had undergone PCNL and open stone surgery. In the study, mean blood loss was significantly higher in patients who had undergone OSS compared to those under the PCNL group (346.05±410.56 vs. 267.6±258.6; p .020 < .05). Similarly, the number of blood bags used on patients under the Open stone surgery was significantly higher compared to patients under the PCNL group (.526±.861 vs. .159±.502, p .000 < .05).

Discussion

One of the major problems encountered in urological practice is urinary stones. An estimated 15% of cases of urological patients suffer from urinary stone concerns. Percutaneous nephrolithotomy (PCNL) is the new standard of care for renal stones >2 cms. Owing to the success of several endoscopic techniques in the past years, PCNL has been regarded to be the most feasible option for patients with complex kidney stones and even among those who have solitary kidney.[15] The procedure is known to be a generally safe in managing cases of large renal calculi with low incidence of complications.[15] Open stone surgery (OSS). persists as a reasonable option for staghorn especially in centers without access to endoscopic stone surgery. OSS is also regularly performed in urology training institutions as part of the requirements for specialty certification. In this study, the authors focused on the comparative difference in the rate of hemorrhage and transfusion between PCNL and OSS.

The authors were able to demonstrate that this hemorrhage and transfusion rates are lower among patients undergoing PCNL. They noted a slight change in the mean level of the platelet, hematocrit, and hemoglobin level of patients under the PCNL group as compared to those under the open stone surgery. The data suggest favorable laboratory parameters on patients under the PCNL procedure. Furthermore, the highest mean average blood loss was observed in patients undergoing OSS as compared to those undergoing PCNL.

While the above findings suggest a safer outcome for the PCNL group, the authors acknowledge that this may not truly reflect the overall safety profile considering all other possible complications that may occur after PCNL such as such as fever, sepsis, thoracic complications, renal vascular injury, extrarenal organ injury and urinoma.[16-17] A study design analyzing all of these complications according to the Clavien-Dindo Classification will be more helpful in understanding the comparative safety of PCNL and OSS, since data gathered were limited to the objectives.

The sample size is unequal between the two groups making inferential conclusions from the two groups weaker. This can be explained by the fact that in their institution, PCNL is preferred procedure for more complex and larger renal stones thus resulting to a wide disparity in the number of cases between OSS and PCNL for more complex renal stones.

The results of the study supported previous studies who also found lower mean blood loss average on patients who had undergone PCNL. Such lower mean average blood loss and complication observed on patients under the aforementioned procedure made them conclude that the procedure is safe as this leads to fewer complications and incidence of mortality.[18-19] Bleeding requiring transfusion is classified as a Grade II Clavien Dindo classification of complications. In this series, no hemorrhage was severe to require interventional radiological procedures in the form of angioembolization nor emergent nephrectomy for damage control.

PCNL is very popular since this carries several benefits such as fewer incidence of morbidities, high satisfaction from patients and immediate resumption to social activities and work.[20] Due to an increasing awareness, many patients with staghorn calculi now request this form of management in contrast to traditional open surgery.

Conclusion

When compared to open stone surgery, PCNL is associated with less hemorrhage and transfusion requirements. Whenever possible, this minimally invasive procedure should be favored given this advantage. On top of that, it offers added potential benefits such as less bodily and renal trauma, less analgesic requirements, faster recovery and early return to functionality.

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