ORIGINAL RESEARCH

Association Between Preoperative Hydronephrosis and Perioperative Outcomes Among Patients Undergoing Percutaneous Nephrolithotomy: A Single-Center Prospective Cohort Study

Dainiel Edgar A. Reyes, MD and Albert T. Aquino, MD, FPUA

Department of Urology, Jose R. Reyes Memorial Medical Center

Background: Staghorn calculi are complicated renal stones that are frequently linked to hydronephrosis, a parameter that can have a major impact on the results of surgery. Percutaneous nephrolithotomy (PCNL) is widely recognized as the gold standard for treating large kidney stones and staghorn calculi. Data on the effect of preoperative hydronephrosis on PCNL perioperative outcomes is still limited.

Objective: This study aimed to investigate the association between preoperative hydronephrosis and perioperative outcomes among patients undergoing PCNL in a tertiary government hospital in Manila.

Methods: A single-center prospective cohort study was conducted, involving 90 patients diagnosed with staghorn calculi and scheduled for elective PCNL. Patients were categorized into two groups based on the presence or absence of moderate-to-severe hydronephrosis as determined by preoperative imaging. Perioperative outcomes, including total operative time, access time, lithotripsy rate, and perioperative complications such as bleeding and sepsis, were evaluated. Data were analyzed using linear and logistic regression models to assess associations between hydronephrosis and perioperative outcomes.

Results: The presence of hydronephrosis was associated with a statistically significant reduction in access time ($p = 0.036$), likely due to the dilation of renal structures facilitating easier entry. However, hydronephrosis was linked to a borderline significant reduction in lithotripsy rate ($p = 0.051$), indicating potential challenges in stone fragmentation. No significant association was found between hydronephrosis and total operative time or perioperative complications, such as bleeding and sepsis.

Conclusion: While hydronephrosis may make kidney access and other technical aspects of PCNL easier, it may also make stone fragmentation more difficult. Larger stone size and stone location were significant predictors of longer operative times and slower lithotripsy rates, underscoring their critical role in surgical outcomes.

Key words: Pre-operative hydronephrosis, staghorn calculi, perioperative outcome

Introduction

Staghorn calculi are upper urinary tract stones that extend into at least two calyces and involve the renal pelvis. In most times, they are composed of struvites (magnesium ammonium phosphate crystals), which are linked to recurrent urinary tract infections by urease-producing pathogens.[1]

The gold standard and primary option for renal stones greater than 20 mm is percutaneous nephrolithotomy (PCNL), according to guidelines published by the European Association of Urology (EAU). It may also be an alternative to retrograde intrarenal surgery (RIRS) for the treatment of stones measuring between 10 mm and 20 mm due to better stone-free rates achieved by a single procedure.[2]

Despite recent advancements, complications are still frequent, affecting almost 25% of patients (23.3%).[3] Infection, bleeding, damage to nearby organs, retained stone, loss of kidney function, and even death can occur as a result of PCNL. Fever was the most frequent complication of all, followed by bleeding.[4] In order to lower the rate of complications and enhance the quality of care provided to patients, it is crucial to investigate the factors that influence PCNL complications.[5] Larger stone sizes have been identified as risk factors that may raise the rates of complications, including bleeding, fever, sepsis, and retained stones following PCNL.[6]

Hydronephrosis was another factor that has been shown to be connected to PCNL success and problems.[7] According to previous research, the lack of hydronephrosis was a predictor of PCNL problems, such as significant bleeding following PCNL, for a number of reasons.[8] The difficulty of accessing the kidney decreases as the degree of hydronephrosis increases. On the other hand, hydronephrosis dilates the calyceal system, and may mobilize stones and complicate ongoing fragmentation during lithotripsy.

In a tertiary government hospital in Manila, the urology department performs around 90-100 PCNL cases per year. Due to their size, location, and possible complications, staghorn calculi are a difficult subset of renal stones. The study's foundation is the clinical difficulties associated with staghorn calculus and PCNL. Kidney stones are commonly connected with the presence of hydronephrosis, a condition characterized by obstruction of the urinary tract that could influence the outcome of surgery. However, even though PCNL is becoming increasingly popular as an effective treatment option, there are still few comprehensive research studies on the precise connection between hydronephrosis and the perioperative outcomes of PCNL, particularly in the Philippines because there are no local data available. Hence, the study aimed to compare the perioperative outcomes of patient undergoing percutaneous nephrolithotomy in patients with pre-operative (moderate to severe) hydronephrosis versus patients with absent-mild hydronephrosis.

The objective of this study was to determine the association between pre-operative hydronephrosis and perioperative outcome among patients undergoing percutaneous nephrolithotomy at a tertiary government hospital in Manila. It determined the demographics of moderate-to-severe hydronephrosis among patients undergoing percutaneous nephrolithotomy based on age, sex and BMI. It also determined the incidence of perioperative complications after PCNL (bleeding and sepsis) and the association between preoperative moderate-to-severe hydronephrosis and perioperative outcomes (Total operative time, access time and lithotripsy rate).

Methods

Study Design

This prospective cohort study examined adult patients undergoing PCNL in a tertiary government hospital in Manila. Data were collected via history, physical examination, direct observation and review of patient charts. Patient participation was up to day of discharge or in-hospital death.

Study Population

Adult patients undergoing percutaneous nephrolithotomy in a tertiary government hospital in Manila from September 2023 to September 2024.

Inclusion criteria

1. Age >18 years old
2. Patients with staghorn calculi confirmed through imaging studies
3. Scheduled to undergo elective PCNL
4. Patients who provided informed consent to participate in the study

Exclusion criteria

1. Patients with severe comorbidities. Severe comorbidities are characterized by patients classified as ASA Physical Status class IV or higher, indicating an elevated risk of perioperative complications.

2. Unwillingness to participate

Withdrawal criteria

1. Deferred surgery
2. Malfunction of equipment
3. Lost to follow-up patients

Sample Size and Sampling Methodology

PASS 2021 software was used to calculate the minimum sample size requirement. Specifying an odds ratio of perioperative complications equal to 5.07[7] and alpha set at 0.05, a minimum of 87 patients were required to achieve 90% statistical power. Sample size was increased to 97 to account for 10% potential dropout.

The researchers utilized a convenience sampling design to select study participants. Consecutive patients who underwent PCNL were invited to participate in the study.

Statistical Analysis

Data were encoded in MS Excel by the researcher. Stata MP version 17 software was used for data processing and analysis. Continuous variables were presented as mean (standard deviation/SD) or median (interquartile range/IQR) depending on the data distribution. Shapiro-Wilk's test was used to assess normality. Categorical variables were presented as frequencies and percentages. Independent t-test or Mann-Whitney U test was used to compare continuous variables, while Chi-square test or Fisher's Exact test was used for categorical variables. Linear regression analysis was conducted to examine the association between moderate-to-severe hydronephrosis and continuous outcomes such as total operative time, access time, and lithotripsy rate. Logistic regression analysis was used to determine the association between moderate-to-severe hydronephrosis and

PASS 2021, v21.0.3 — 25 Aug 2023 10:05:36 am — 1

Logistic Regression (Legacy)

Numeric Results

Power	N	Pcnt N X=1	P0	P1	Odds Ratio	R Squared	Alpha	Beta
0.79355	87	39	0.125	0.42	5.06897	0.2	0.05	0.20645

References

Hsieh, F.Y., Block, D.A., and Larsen, M.D. 1998. 'A Simple Method of Sample Size Calculation for Linear and Logistic Regression', Statistics in Medicine, Volume 17, pages 1623-1634.

Report Definitions

Power is the probability of rejecting a false null hypothesis. It should be close to one.
N is the size of the sample drawn from the population.
P0 is the response probability at the mean of X.
P1 is the response probability when X is increased to one standard deviation above the mean.
Odds Ratio is the odds ratio when P1 is on top. That is, it is [P1/(1-P1)]/[P0/(1-P0)].
R-Squared is the R2 achieved when X is regressed on the other independent variables in the regression.
Alpha is the probability of rejecting a true null hypothesis.
Beta is the probability of accepting a false null hypothesis.

Summary Statements

A logistic regression of a binary response variable (Y) on a binary independent variable (X) with a sample size of 87 observations (of which 61% are in the group X=0 and 39% are in the group X=1) achieves 79% power at a 0.05 significance level to detect a change in Prob(Y=1) from the baseline value of 0.125 to 0.42. This change corresponds to an odds ratio of 5.06897. An adjustment was made since a multiple regression of the independent variable of interest on the other independent variables in the logistic regression obtained an R-Squared of 0.2.

perioperative complications (e.g., bleeding, sepsis). Missing values were neither replaced nor estimated. P-values ≤ 0.05 were considered statistically significant.

The data collection for this study involved prospectively collecting data from patients who underwent PCNL for the treatment of kidney stones. Patients who met the inclusion criteria were approached and provided with an explanation of the study.

The researcher oriented the RODs assigned to the outpatient department and hospital ward regarding the study. Recruitment took place at the outpatient department and hospital ward. Patients scheduled to undergo elective PCNL were referred to the researcher for further screening and consent administration.

The researcher explained the study objectives, procedures, risks and benefits to each eligible patient. In order to affirm voluntary participation, patients were asked to sign a written consent form.

After obtaining informed consent, baseline demographic data were collected through face-to-face interview. Data included age, sex, and body mass index (BMI). Baseline data were recorded in a Baseline Data Collection Form.

The diagnosis was established through a preoperative CT scan done within 6 months, with all CT images assessed by a radiologist. Patients were categorized into two groups based on the presence or absence of moderate to severe hydronephrosis.

Antibiotic prophylaxis was administered consistently to all patients in accordance with a standard dosage regimen. The PCNL procedure was done by the Senior urology residents assisted by a urology consultant/fellow. Following the administration of anesthesia, a ureteric catheter was introduced and secured to a Foley catheter. The patient was then positioned in the prone position. A retrograde pyelogram was performed, and an initial puncture was carried out using an 18-gauge needle, followed by progressive tract dilation. An 18 Fr Amplatz sheath with suction capability was introduced. Subsequently, a 12 Fr rigid nephroscope was utilized for lithotripsy, employing an EMS pneumatic lithoclast. Prior to concluding the procedure, a nephrostomy tube was inserted.

Outcome Assessment

Two independent outcome assessors, not involved in any other study procedure and blinded to presence of preoperative hydronephrosis, collected the outcomes of interest. These data were recorded in an Outcome Assessment Form.

Total operative time, access time and lithotripsy time were obtained via chart review. A post-operative CBC was obtained and patients were monitored daily at the hospital ward for any complications, including sepsis and bleeding.

Results & Discussion

A total of 90 patients were included in the study where proportion of hydronephrosis was 48.9%. Their mean age was around 50 years old (SD=13.2) and they were mostly male (64.4%). Only 36.7% had normal BMI while 44.4% were pre-obese, 8.9% classified as obese I and 6.7% obese II. The average stone size was 743.3 (SD=646.7) while 56.7% of them had multiple stone location. Thirty percent of stones were located on the renal pelvis. Results further revealed no significant difference on the mean age, sex distribution, BMI and stone size between patients with and without hydronephrosis. On the other hand, significant difference existed on stone location where having multiple locations is associated among those without hydronephrosis. On the other hand, renal pelvis was significantly associated with hydronephrosis.

Table 3 shows that hydronephrosis is not significantly associated with total operative time. In the crude model, the presence of hydronephrosis was associated with a reduction of 2.24 minutes in total operative time ($\beta = -2.24$, 95% CI: -20.32, 15.83, $p = 0.8057$). After adjusting for confounders like stone size and stone location, hydronephrosis was associated with a slight, non-significant increase in operative time ($\beta = 7.91$, 95% CI: -10.31, 26.13, $p = 0.39$). Importantly, stone size significantly affected total operative time, with each additional millimeter of stone size associated with an increase in operative time by 0.017 minutes ($\beta = 0.017$, 95% CI: 0.003, 0.031, $p = 0.015$).

In table 4, the crude model, hydronephrosis was not significantly associated with access time ($\beta = -1.67$, 95% CI: -5.79, 2.45, $p = 0.4228$). However, after adjusting for confounders, hydronephrosis was associated with a statistically significant reduction in access time, with patients with hydronephrosis showing a 4.94-minute shorter access time (β = -4.94, 95% CI: -9.55, -0.32, p = 0.036). This suggests that hydronephrosis may facilitate easier access to the kidney during surgery, potentially due to the dilation of the renal structures. Additionally, stone size was significantly associated with access time in both crude and adjusted models. For every additional millimeter in stone size, access time increased by 0.0123 minutes (β = 0.0123, 95% CI: 0.0088, 0.0158, p < 0.001), reflecting the technical difficulty in accessing larger stones.

Table 5 shows the presence of hydronephrosis was associated with a lower lithotripsy rate, though this was a borderline significant result. In the crude model, hydronephrosis reduced the lithotripsy rate by 4.82 mm/min (β = -4.82, 95% CI: -9.88, 0.24, p = 0.0616). After adjusting for confounders, the reduction was slightly larger, with patients with hydronephrosis having a 5.11 mm/min slower lithotripsy rate (β = -5.11, 95% CI: -10.26, 0.03, p = 0.051), but the result remained on the borderline of statistical significance. This suggests that hydronephrosis may negatively impact the efficiency of stone fragmentation during lithotripsy.

Table 6 shows the association between hydronephrosis and the likelihood of developing perioperative complications, specifically sepsis and bleeding, using both crude and adjusted odds ratios (ORs). This was done through logistic regression to assess whether hydronephrosis significantly affects the odds of these complications after accounting for potential confounders such as age, BMI, gender, stone size, and stone location.

Table 1. Demographic and clinical characteristics of patients .

	All	Hydronephrosis		p value
		Yes	No	
n	**90**	**44**	**46**	
Age (years), mean ± sd	49.6 ± 13.2	51 ± 12.5	48.2 ± 14	0.3013
Sex				
Male	58 (64.4)	30 (68.2)	28 (60.9)	0.4713
Female	32 (35.6)	14 (31.8)	18 (39.1)	
BMI				
Underweight	3 (3.3)	1 (2.3)	2 (4.3)	0.7808
Normal	33 (36.7)	17 (38.6)	16 (34.8)	
Overweight	40 (44.4)	18 (40.9)	22 (47.8)	
Obesity I	8 (8.9)	3 (6.8)	5 (10.9)	
Obesity II	6 (6.7)	5 (11.4)	1 (2.2)	
Stone size, mean ± sd	743.3 ± 646.7	693.6 ± 759.2	789.6 ± 524.8	0.0578
Stone Location				
Multiple	51 (56.7)	20 (45.5)	31 (67.4)	0.0281
Renal pelvis	27 (30.0)	19 (43.2)	8 (17.4)	
Others	12 (13.3)	5 (11.4)	7 (15.2)	
Inferior Pole	7 (7.8)	2 (4.5)	5 (10.9)	
Middle Pole	2 (2.2)	2 (4.5)	0 (0.0)	
Upper Pole	3 (3.3)	1 (2.3)	2 (4.3)	

Table 2. Clinical outcomes of patients.

	All	Hydronephrosis		p value
		Yes	No	
n	**90**	**44**	**46**	
Total Operative Time (Minutes), mean ± sd	105.8 ± 42.6	104.6 ± 39.3	106.8 ± 45.9	0.9313
Access Time (Minutes), mean ± sd	17.6 ± 9.7	16.7 ± 7.1	18.4 ± 11.7	0.8239
Lithotripsy Rate (mm/min), mean ± sd	16.14 ± 12.19	13.49 ± 10.72	18.95 ± 13.18	0.0291
Perioperative complications				
Yes	20 (21.3)	11 (25.6)	9 (17)	0.3191
No	70 (77.5)	31 (72.1)	38 (80.9)	
Sepsis	11 (12.4)	6 (14)	5 (10.6)	0.6904
Bleeding	9 (10.1)	5 (11.6)	4 (8.5)	0.7365

Table 3. Association between hydronephrosis and total operative time.

	Crude β	(95% CI)	p value	Adjusted β	(95% CI)	p value
Hydronephosis	-2.24	(-20.32,15.83)	0.8057	7.91	(-10.31,26.13)	0.39

Table 4. Association between hydronephrosis and access time.

	Crude β	(95% CI)	p value	Adjusted β	(95% CI)	p value
Hydronephosis	-1.67	(-5.79, 2.45)	0.4228	-4.94	(-9.55, -0.32)	0.036

Table 5. Association between hydronephrosis and lithotripsy rate.

	Crude β	(95% CI)	p value	Adjusted β	(95% CI)	p value
Hydronephosis	-4.82	(-9.88, 0.24)	0.0616	-5.11	(-10.26, 0.03)	0.051

Table 6. Association between hydronephrosis and perioperative complications.

Bleeding

	Univariate			Multivariate		
	Crude OR	95% CI	p value	Adjusted OR	95% CI	p value
Hydronephosis	1.38	(0.35,5.53)	0.6481	1.26	(0.26,6.11)	0.7721

Sepsis

	Univariate			Multivariate		
	Crude OR	95% CI	p value	Adjusted OR	95% CI	p value
Hydronephosis	1.33	0.37,4.72	0.6594	2.22	(0.50,9.79)	0.2921

For sepsis, the crude odds ratio indicates that hydronephrosis was associated with a 33% increase in the odds of developing sepsis during the perioperative period (Crude OR: 1.33, 95% CI: 0.37, 4.72). However, this result was not statistically significant (p = 0.659), as reflected by the wide confidence interval, which suggests uncertainty in the estimate. After adjusting for confounders, the odds of sepsis in patients with hydronephrosis more than doubled (Adjusted OR: 2.22, 95% CI: 0.50, 9.79), but this result also remained not statistically significant (p = 0.292). Although the adjusted model shows a larger increase in the odds of sepsis in the presence of hydronephrosis, the lack of statistical significance indicates that the relationship between hydronephrosis and sepsis is weak and likely influenced by other factors.

For bleeding, the crude odds ratio showed that hydronephrosis was associated with a 38% increase in the odds of perioperative bleeding (Crude OR: 1.38, 95% CI: 0.35, 5.53). However, this association was not statistically significant (p = 0.648). Similarly, after adjusting for confounders, the odds of bleeding in patients with hydronephrosis remained slightly elevated (Adjusted OR: 1.26, 95% CI: 0.26, 6.11), but this result was also not statistically significant (p = 0.772). These findings suggest that hydronephrosis does not play a significant role in increasing the risk of bleeding during the perioperative period.

The aim of this study was to look at the association among patients undergoing percutaneous nephrolithotomy with preoperative hydronephrosis and perioperative outcomes. The study investigated the lithotripsy rate, total operating time, access time, and perioperative complications, including bleeding and infection.

Hydronephrosis and Total Operative Time

There was no discernible correlation between the amount of time spent during surgery and the presence of hydronephrosis. The crude model indicated a weak and non-significant correlation between hydronephrosis and a shorter operating time. subsequently after adjusting for variables including the location and size of the stone, hydronephrosis was associated with a little increase in overall operating time; however, this association was not statistically significant. The influence of stone size was more pronounced, with each additional millimeter of stone size leading to a significant increase in operative time. This aligns with previous studies that have identified larger stone sizes as a key factor in prolonging operative time due to the technical difficulties posed by their removal.

Hydronephrosis and Access Time

It is interesting to note that in the adjusted model, hydronephrosis was found to considerably decrease access time. Due to the dilatation of the renal collecting system, patients with this parameter had faster access to the collecting system during PCNL. The additional space in the renal pelvis and calyces likely contributed to easier puncture and navigation to the stones, which reduced the amount of time needed to gain access. This finding supports the notion that moderate-to-severe hydronephrosis can simplify certain technical aspects of PCNL.

Hydronephrosis and Lithotripsy Rate

The lithotripsy rate was shown to be a bit significantly lower in patients with hydronephrosis, indicating a tendency for slower stone fragmentation. The lithotripsy rate decreased according to the crude model, but it decreased even more according to the corrected model, although it remained on the threshold of statistical significance. This result suggests the possibility that hydronephrosis could impede stone breakup during PCNL because of the stones' greater mobility in the dilated renal pelvis and calyces. When these structures dilate, it may be more difficult to stabilize the stones during lithotripsy, which reduces the effectiveness of fragmentation.

Hydronephrosis and Perioperative Complications

In both crude and adjusted models, the relationship between hydronephrosis and perioperative complications—more especially, bleeding and sepsis—was not statistically significant. In the basic model, hydronephrosis was linked to a 33% increase in the odds of sepsis, and in the adjusted model, this risk more than doubled. Nevertheless, neither of these results attained statistical significance. The broad confidence intervals show ambiguity and suggest that sepsis risk may be more significantly influenced by other factors, such as the amount of stone burden or pre-existing infections.

Similarly, there was a marginally significant correlation found between hydronephrosis and an increased risk of bleeding. The modified model indicated a little increase in the risk of bleeding, which may be related to the technical difficulties caused by hydronephrosis during stone removal. While hydronephrosis makes access easier, in individuals with severe hydronephrosis, the thinner renal cortex may also increase the risk of bleeding. Due to their thinner renal cortex, patients with hydronephrosis may be more susceptible to bleeding during surgery. The delicate, stretched tissue may bleed more easily when punctured or manipulated.

Conclusion

This study evaluated the impact of moderate-to-severe hydronephrosis on perioperative outcomes in patients undergoing percutaneous nephrolithotomy. While hydronephrosis did not have a statistically significant association with total operative time or perioperative complications, it was linked to a significant reduction in access time, likely due to the dilated renal structures facilitating easier entry. Conversely, hydronephrosis was associated with a borderline significant reduction in lithotripsy rate, indicating challenges in stone fragmentation during surgery.

Overall, the findings suggest that while hydronephrosis may ease certain aspects of the procedure, such as kidney access, it may also introduce complexities in stone management underscoring its critical role in surgical outcomes. Future research should focus on evaluating long-term outcomes and optimizing surgical techniques for patients with hydronephrosis, especially those presenting with larger or more complex stone burdens, to further enhance treatment efficacy and patient safety.

Conflict of Interest: All researchers involved in the study declare no conflicts of interest that could potentially bias the study design, conduct, or outcomes.

By adhering to these ethical considerations, this study aimed to uphold the highest standards of research ethics, ensuring the well-being of participants and the integrity of the research process.

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