THE ASSOCIATION BETWEEN S.T.O.N.E. NEPHROLITHOMETRY SCORE AND HEMOGLOBIN DROP IN PATIENTS UNDERGOING PERCUTANEOUS NEPHROLITHOTOMY

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ABSTRACT

Nephrolithiasis is a very common condition with significant burden to patients. Percutaneous nephrolithotomy (PCNL) is safe procedure considered as gold standard for large renal stones. The most common complication of PCNL is bleeding which can require blood transfusion to angioembolization and may even need nephrectomy. The purpose of this study is to assess if STONE Nephrolithometry Score can predict hemoglobin drop in PCNL procedure. A total of 104 patients who underwent PCNL during one year period from October of 2022 to September of 2023 were taken using consecutive sampling method. All patients with renal stones underwent routine blood tests including complete blood counts, renal function and electrolytes. CT scans were then done and STONE nephrolithometry Score was evaluated. PCNL was performed and hemoglobin investigation was sent at 24 hours postoperatively. The two data were compared with the STONE nephrolithometry Score and other factors. More than three-fourths (78.8%) of the patients had comorbidities with hypertension being the commonest (76.9%). There was a significant association of drop of hemoglobin more than 1 g/dl with age <30 years (p <0.034), higher preoperative hemoglobin (p <0.046), larger stone size (p <0.001), shorter tract length (p=0.017) and STONE Score greater than 10 (p<0.001). On correlation study only STONE score (p = 0.015) and larger stone size (p = 0.002) were associated with hemoglobin drops of more than 1 g/dl. STONE Nephrolithometry score is a good predictor of bleeding complications during PCNL and higher score is associated with more drop in hemoglobin levels.

KEYWORDS

STONE nephrolithometry score, PCNL, hemoglobin, complication

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INTRODUCTION

Nephrolithiasis is a very common condition with significant burden to patients affecting between 10 to 15% of the world's population.[1,2] With vast improvements in technology and techniques, minimally invasive procedures such as shock wave lithotripsy (SWL), ureteroscopy are considered first-line therapy for most stones.[3] Percutaneous nephrolithotomy (PCNL) has been advocated as standard treatment for larger and complex renal stones (>2cm), lower pole renal stones, and stones with unfavorable composition (i.e. cysteine, brushite, calcium oxalate monohydrate).[4]

PCNL is minimally invasive, safe and highly effective procedure however serious complications are encountered. Bleeding is common although often minimal and self-limiting, it can be life threatening requiring transfusion and angioembolization in rare cases.[5] It is affected by a multitude of factors from patient factors to stone factors.[6-8] Stone complexity is one of the factors that correlate with postoperative hemoglobin drop. There are many scoring systems and one of them is the STONE score. The STONE score is calculated using five variables, abbreviated as the acronym STONE.[9] So the aim of this study was to find if STONE score can correlate with postoperative hemoglobin drop after a PCNL procedure.

The general objective of this study was to associate between STONE Nephrolithometry Score and hemoglobin drop in patients undergoing PCNL. Further specific objectives were to evaluate various factors assessing stone complexity i.e. stone number, stone size, stone location, number of calyces involved, density of stone, anatomy of the kidney, tract length and presence of hydronephrosis, to evaluate the drop in hemoglobin level and to compare the STONE Nephrolithometry Score and drop in hemoglobin level.

MATERIALS AND METHODS

This was a hospital based observational study from October 2022 to September 2023 done at Nepal Medical College Teaching Hospital which included all patients undergoing PCNL procedure using a consecutive sampling technique. All patients undergoing PCNL surgery were included in the study. Patients excluded in this study were those who've undergone PCNL, nephrostomy or open renal surgeries in the past, petient who had undergone additional procedures such as OIU, TURP, URS along with PCNL, patients without CT Urography, patients under anticoagulants, patients with skeletal deformity who are unable to position for the surgery, patients needing multiple tract or double setting operation and those who had both side kidney surgery.

Preoperative assessment: Prior to scheduling PCNL, complete history and physical examination of all patients was done. Preoperative investigations i.e. complete blood count (CBC), hematocrit, renal function test (RFT), urine routine examination and culture/ sensitivity test, bleeding profile, serology, blood grouping and Rh typing, ECG, chest X-Ray, CT urography were done.

Radiologist in the Department of Radiology measured the stone complexity variables such as stone size, tract length, degree and presence of obstruction (hydronephrosis), number of involved calyces, and stone essence (density). Each of the variables were scored according to the predefined system proposed by Okhunov *et al*[10] and the STONE nephrolithometry score was calculated. Finally all patients underwent PCNL only after negative urine culture was confirmed.

Surgical technique of PCNL: Patient under general anesthesia, in the lithotomy position, cystoscopy was done and ureteric catheter of 6 Frenz was negotiated up to renal pelvis under fluoroscopic guidance in the operating kidney. After this foley catheterization was done and position changed to prone. Under fluoroscopic guidance, with the help of contrast instilled through the ureteric catheter placed before, desired calyx was punctured with 18 gauze Chiba needle via infracostal / supracostal approach. Entry into pelvi-calyceal system was confirmed by aspiration of urine mixed contrast in a syringe from the puncturing needle. A 0.035-inch Terumo guidewire with straight tip was introduced into the calyceal system to the ureter via the needle to secure the tract. Tract was dilated with metallic alken dilators up to 18 Frenz followed by insertion of amplatz sheath of 18 Frenz. A 12 Frenz Nephroscope was then introduced through the amplatz sheath and thorough inspection of the pelvi-calyceal system was done along with visualization of stone and its location. Stone was then fragmented with pneumatic/laser lithotripter. Fragmented stones were removed by flushing with irrigation saline or by retrieving with a stone grasper. Multiple tracts were created to clear the stones if required but these cases were not included in the study. Stone clearance was confirmed by direct visualization of pelvi-calyceal system through the nephroscope along with the help of fluoroscopy. Ureteral catheter placed earlier was then removed and a double J stent of 6 Frenz was introduced into the ureter up to the urinary bladder via amplatz sheath with the help of guidewire antigradely. Proximal tip of the double J stent in the renal pelvis was confirmed by direct visualization through nephroscope. Puncture site was closed with 2-0 silk without keeping nephrostomy tube.

Follow-up was done on first post-operative day with the investigations like complete blood count, Hematocrit level and renal function test. Stone clearance was checked by plain X-Ray KUB on the 3rd post-operative day and urine culture/sensitivity test was repeated after removal of foley catheter on 3rd post-operative day.

Estimation of blood loss: Blood loss was calculated by comparing preoperative hemoglobin and hematocrit levels done 24 hours before surgery to 24 hours after PCNL procedure.[11]

Sample size calculation: The sample size was calculated using following formula:

$$n=\frac{z^2pq}{d^2}$$

Operational Definition

STONE nephrolithometry score: The STONE nephrolithometry score proposed by Okhunov *et al*[10] integrates five components measured from non-contrast/contrast enhanced (NCECT/CECT) images before surgery to provide a picture of the complexity that can affect the percutaneous management of renal stones. The components are abbreviated as an acronym STONE i.e. stone size, tract length (skin-to-stone distance), degree of obstruction, number of calyces involved and stone essence (density).

The stone size was estimated by combining the measures of length and width in square millimeters. The stone size was scored from 1 to 4 according to a calculated area of 0-399, 400-799, 800-1599, and >1600 mm^2, respectively. The tract length evaluates the skin-to-stone distance. The skin-to-stone distance was defined as the mean vertical distance from the center of the stone to the skin measured on a supine non-contrast-enhanced CT film at 0-degree, 45-degree and 90-degree.

The tract length was scored according to a mean length of 100 mm. This cutoff was determined according to the distances calculated in patients with a body mass index (BMI) of 30 kg/m^2. A BMI of 30 kg/m^2 was selected, because it is the currently accepted cutoff for obesity.

The third variable obstruction, evaluates the degree of hydronephrosis and was scored according to the severity of dilation of the collecting system. No obstruction or mild dilation was assigned 1 point and moderate to severe dilation was assigned 2 points.

The fourth component assesses the number of calyces containing stones. If only a single calyx was involved, a score of 1 was assigned. If 2 or 3 calices were affected, a score of 2 was assigned. A maximum score of 3 was assigned if a full staghorn calculus was present.

The last variable is the stone essence, which evaluates the stone density. This was measured on preoperative CT imaging and was assigned a score according to a radio density threshold of >950 or <950 Hounsfield units.

Data collection and analysis: Data was analyzed using SPSS-16. Continuous variables such as age and the STONE score were described in terms of mean/median and standard deviations. For post-operative hemoglobin drop, mean difference (preoperative and postoperative hemoglobin) was assessed by paired t-test. Categorical variables such as gender was described in terms of frequencies and percentages. The correlation between the

Table: Summary of STONE nephrolithometry scoring system

Variables	Score			
	1	2	3	4
Stone size (mm^2)	0-399	400-799	800-1599	>1600
Tract length (mm)	100	>100		
Obstruction (degree of hydronephrosis)	None or mild	Moderate or severe		
Calyces involved (n)	1-2	3	Staghorn calculus	
Stone Essence (HU)	<950	>950		

The scores from each variable are added to obtain the S.T.O.N.E. Nephrolithometry Score (min=5, max =13).

STONE score and postoperative hemoglobin drop was measured by the Pearson correlation/ Spearman correlation coefficient as appropriate.

RESULTS

A total of 104 patients were taken in this study with males forming two-thirds of the population. The majority of patients were from 30-50 years age group (54.8%). More than three-fourths of the patients had comorbidities with HTN having the largest share (76.9%). Left sided stones were nearly as twice common as right sided as shown in table 1.

The mean STONE score was 10.71 with 58.7% having score of more than 10 which can be attributed to the moderate to severe degrees of obstruction in 76% and involvement of 3 or more calyces in 53.8%. The stones sizes ranged from 870mm^2 to 1870mm^2 with 29 patients having stone sizes greater than 1600mm^2 as shown in Table 2.

All patients were found to have a drop in hemoglobin by 1 g/dl or less (42.3%) and by more than 1 g/dl (57.7%). Two patients required blood transfusion and one had to undergo angioembolization. Upon statistical analysis a significant drop in hemoglobin by 1 g/dl or more was found in younger age group of less than 30 years, higher preoperative hemoglobin, larger stone size, higher STONE score and shorter tract lengths as shown in Table 3.

When above significant parameters were analyzed using a correlation study, STONE score and stone size had significant correlation with drop in hemoglobin of 1g/dl or more as shown in Table 4.

Table 1: Demographic Profile and baseline stone-related and clinical parameters

Parameters	**Frequency (n =104)**	**Mean (± SD)**
Age (years)	**n (%)**	43.94±11.77
Less than 30 years	12 (11.5)	
30-50 years	57 (54.8)	
More than 50 years	35 (33.7)	
Gender		
Male	66 (63.5)	
Female	38 (36.5)	
Chronic disease		
No	22 (21.2)	
HTN	77 (74.0)	
DM	2 (1.9)	
DM and HTN	3 (2.9)	
Average Pulse (beats/min)		84.58 ± 10.02
Side of surgery		
Left	70 (67.3)	
Right	34 (32.7)	
Blood pressure		
Non Hypertensive	24 (23.1)	
Hypertensive	80 (76.9)	
Preoperative hemoglobin (g/dl)		13.50 ± 3
Preoperative hematocrit (mg/dl)		40.50 ± 8.9
Postoperative hemoglobin (g/dl)		12.38 ± 1.64
Postoperative hematocrit (mg/dl)		37.15 ± 4.94
Drop in hemoglobin (g/dl)		1.216 ± 1.03
< 1 g/dl	44 (42.3%)	
≥ 1 g/dl	60 (57.7%)	
Hospital stay (Days)		4.18 ± 0.67

Table 2: Stone-related parameters, calyces involved, and degree of obstruction

Parameters	Frequency (%)	Mean ± SD
Stone score		10.71 ± 1.26
Moderate risk (≤10)	43 (41.3)	
High risk (>10)	61 (58.7)	
Stone size (mm²)		1282 ± 290.09
800- 1599	75 (72.1)	
>1600	29 (27.9)	
Tract length (mm)		107.82 ± 8.52
<100	12 (11.5)	
>100	92 (88.5)	
Obstruction		
None or mild	25 (24)	
Moderate or Severe	79 (76)	
Calyces Involved (n)		
1-2	35 (33.7)	
3	56 (53.8)	
Staghorn calculus	13 (12.5)	
Stone density (HU)		1261. 47 ± 175.47
>950	104 (100)	

Table 3: Comparison of the groups regarding various outcome parameters in patients who had < or >1 gm/dl hemoglobin drop

Parameters	Hemoglobin drop of <1 n (%)	Hemoglobin drop of >1 n (%)	p-value
Gender			
Male	24 (36.4)	42 (63.6)	.106
Female	20 (52. 6)	18 (47.4)	
Chronic disease			
Presence	6 (40)	9 (60)	.845
Absence	38 (42.7)	51 (57.3)	
Age group			
< 30 yrs	1(8.3)	11(91.7)	.034*
30-50 yrs	28 (49.1)	29 (50.9)	
>50 yrs	15 (42.9)	20 (57.1)	
Blood pressure			
Non hypertensive	14 (58.3)	10 (41.7)	.070
hypertensive	30 (37.5)	50 (62.5)	
Site of surgery			
Left	31 (44.3)	39 (55.7)	.558
Right	13 (38.2)	21 (61.8)	
Preoperative hemoglobin (gm/dl)	13.23 ±1.51	13.86 ± 1.60	.046*
Postoperative hemoglobin (gm/dl)	12.62 ± 1.50	12.20 ± 1.73	.198
Preoperative hematocrit (mg/dl)	39.71 ± 4.53	41.59 ± 4.81	.046*
Postoperative hematocrit (mg/dl)	37.88 ± 4.50	36.61 ± 5.21	.198
Stone size (mm²)	1130.48 ± 219.024	1394.70 ± 286.206	<0.001***
STONE score	9.95 ± 1.140	11.27 ± 1.056	<0.001***
Tract Length (mm)	110.14 ± 7.473	106.12 ± 8.903	.017*

significant at the 0.05 level * significant at the 0.01 level*

Table 4: Correlations of the STONE scores and individual parameters with hemoglobin drop		
Variables	**Correlation coefficient**	**P-value**
Total STONE Score	.238	.015*
Stone size (mm^2)	.297	.002**
Tract length (mm)	-.071	.473
Stone density (Hounsfield units)	.131	.186

*Correlation is significant at the 0.05 level, ** Correlation is significant at the 0.01 level

DISCUSSION

PCNL is a minimally invasive procedure considered safe and highly effective yet serious complications can be encountered. One such dreaded complication is bleeding. Most often it is self-limiting and minimal but occasionally it can become life threatening requiring transfusion to angioembolization and even may need of nephrectomy. Studies have cited blood transfusion rates as high as 23.8%.[12] Various methods from ultrasound-guided approach, miniaturization of instrument, tubeless PCNL and using balloon catheter nephrostomy tube have been described to reduce bleeding. Those with lower transfusion rates in their studies have cited younger age,[13] supine position[14] and balloon dilator use[15,16] as possible reasons. However our study found that younger patients of less than 30 years had a significant drop in hemoglobin by 1 or more (p = 0.34) which can be an incidental finding.

Focus has shifted over the identification of possible bleeding complication beforehand by using scoring systems and one such score is the STONE score. After being proposed by Okhunov *et al*[10] in 2013 who used the term estimated blood loss (EBL), the STONE score has been validated by many studies as a good predictor for stone free rates and postoperative complications including bleeding.[17-20] Literature is also abundant regarding STONE score and EBL which is often difficult to quantify. However hemoglobin measurement is a more direct and definitive assessment.

Our study shows that all the patients had a drop in hemoglobin level. A drop in hemoglobin by 1 g/dl or more was significantly associated with higher STONE score of more than 10. Shoaib *et al*[11] in 2020 found that higher STONE score of more than 9 was significantly associated with greater hemoglobin drop (p=0.05). Larger size stones was the other significant association (p=0.03) which is a similar observation to ours (p<0.001). A particular highlight is on the tract length where in shorter tracts were associated with more drop in hemoglobin in their study which is similar to our study findings of more hemoglobin drop with shorter tract length. (p=0.017) Similarly Noureldin *et al*[18] found in their study that EBL of 250 ml and more was seen when mean STONE score was more than 8.3. However the same authors performed another study comparing Guy's score with STONE score and found that while both predicted EBL good accuracies, there were no significant associations between both scoring systems and complications (p=0.7 and 0.6).[19]

The mean drop of hemoglobin in this study was 1.2 g/dl. Zehri *et al*[21] reported a mean drop of 1.68 g/dl which is higher than this study and they also had a higher transfusion rates of 14.2% with 33 patients requiring blood transfusion. An interesting observation noted in this study was a significant association between higher preoperative hemoglobin levels (mean 13.86 g/dl) and greater drop in postoperative hemoglobin levels (mean 1.66 g/dl). Similar findings were found by Shoaib *et al*[10] who reported mean preoperative hemoglobin of 13.7 g/dl and a drop of 1.76 g/dl. This needs to be further analyzed to identify the clinical implications.

Among the other parameters used in STONE score, only stone size (p<0.001) and tract lengths (p<0.017) were found to be associated with bleeding. However a correlation study identified only stone size to be significant. This is very similar to the studies done by Okhunov *et al*[10] and Shoaib *et al.*[11] The mean stone size was 1282 mm^2 and 27.9% patients had stones larger than 1600 mm^2. A study by Syahputra *et al*[22] also concluded similarly that higher stone burden and staghorn calculus were associated with a significant drop in hemoglobin. While larger stone requiring greater intra-renal manipulation was cited as a reason for bleeding, this forms only a part of PCNL surgery and bleeding can occur from the first step of puncture and gaining access. However a study by Senocak *et al*[23] found that in pediatric patients, stone size and staghorn have a lesser impact and more role is played by degree of hydronephrosis (p=0.021), number of tracts (p=0.032) and longer operating times (p=0.007). Hydronephrosis as referenced in our study by degree of obstruction was found in 76% and contributed to a higher STONE score but when considered as a single entity, it was not associated with bleeding (p=0.56). Others[23-25] have also found that multiple access tracts and multiple punctures relate to bleeding. Our study has not included these cases due to possibility of confounding.

Regarding the technique of PCNL, Turna *et al*[12] found significant association of staghorn stones, single but large stones multiple tracts during PCNL, diabetes and method of dilation. Of note they found that Amplatz sheath dilators had a greater drop in hematocrit than balloon dilators (9.1 vs 6.2). At our institute we regularly use Amplatz sheath dilators and the mean drop in hematocrit of 3.45 is quite lower than the drops found in their study for either Amplatz or balloon.

This study can have a few limitations. The Urologist was not blinded from the study procedure. It is unknown whether the exact cutoffs used in STONE Score for tract lengths and stone density are optimal.[17] The STONE Score itself has not been validated by a large randomized trial.

PCNL is a standard procedure for renal stones and is very commonly performed with good safety. As with any surgical procedure, bleeding is the most common complication and can become deadly. STONE nephrolithometry score can be easily obtained using just the CT scans which are routinely done as preoperative workup of patients prior to PCNL and it is a good evaluator of PCNL related blood loss. So we recommend surgeons to incorporate preoperative assessment using STONE neprhrolithometry score in their practice.

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