STONE Score: A Predictor for Need of Blood Transfusion in Percutaneous Nephrolithotomy

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ABSTRACT

Objective: To determine if the STONE score is a predictor of blood transfusion and if patient-related factors, i.e., the presence of comorbidities such as urinary tract infection and obesity, can predict blood transfusion post-percutaneous nephrolithotomy.

Study Design: A cross-sectional descriptive study.

Place and Duration of the Study: Department of Urology, The Aga Khan University Hospital, Karachi, Pakistan, between March 2022 and 2023.

Methodology: All patients admitted for percutaneous nephrolithotomy (PNCL) were included in the study. STONE score and patient related factors were assessed. Chi-square or Fisher's exact test was applied to check the association between the dependent variables (blood transfusion) and the independent variables. Logistic regression analysis was applied to compare the variables responsible for the outcome.

Results: During the study period, 150 patients underwent PCNL. After exclusion, 89 patients were included in the study. The mean STONE score was 7.87, and the total number of transfusions was 8 (8.9%). BMI (body mass index) >25kg/m^2 and STONE score were found to be significant factors predicting the need for transfusion with p-values of 0.02 and 0.03, respectively. On multivariate analysis, only BMI was found to be a significant contributing factor for blood transfusion.

Conclusion: High BMI and STONE score are significant predictive factors for blood transfusion post-PCNL. Blood product arrangements should be restricted to obese patients.

Key Words: *STONE score, Body mass index, Blood transfusion.*

How to cite this article: Saeed A, Aziz W, Hashmi AP, Ather H. STONE Score: A Predictor for Need of Blood Transfusion in Percutaneous Nephrolithotomy. *J Coll Physicians Surg Pak* 2024; **34(05)**:578-583.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is a standard surgical treatment for kidney stones greater than 2 cm.[1] Fernstorm and Johanson reported the first fluoroscopic stone removal through a percutaneous nephrostomy.[2] Over the years, the technique of PCNL has seen major modifications. PCNL, though a minimally invasive technique, is associated with some complications. Some of the most significant complications of PCNL are bleeding, the need for blood transfusion, and angioembolisation.[3] Bleeding can occur during puncture, instrument manipulation, and stone fragmentation due to parenchymal injury, but in majority cases it is mainly due to injury to interlobar and segmental renal vessels.[4]

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Received: December 08, 2023; Revised: March 27, 2024; Accepted: April 14, 2024
DOI: https://doi.org/10.29271/jcpsp.2024.05.578

Several factors, like diabetes,[5] hypertension,[6] intraoperative time,[6] obesity,[7] stone size,[7] multiple puncture tracts,[8] urinary tract infection,[9] and stone complexity[10] have been shown to predict blood loss during PNCL. Stone complexity may be objectively assessed by several scoring systems, including Guy's scoring system, the STONE score, and the CROES nomogram. The STONE score is composed of five reproducible variables based on non-contrast enhanced CT KUB, abbreviated using the acronym S.T.O.N.E. These variables include Stone volume, Tract length, degree of Obstruction, Number of calyces involved with stone, and Essence (Hounsfield unit).[11] Multiple studies have shown the validity and reliability of STONE, Guy's stone score and CROES nomogram. No comparative work has so far shown the superiority of one scoring system over another.

One of the audits at the institution showed the utility of the STONE score in predicting the haemoglobin drop;[12] however, there is a dearth of prospective studies. In most centres, ordering blood products is based on clinical judgment rather than objective criteria. This practice has obvious implications for cost and increasing the workload on the blood bank. The current study aimed to assess the utility of the STONE score in predicting the need for transfusion in patients undergoing PCNLs and determine patient-associated factors for the same.

METHODOLOGY

This cross-sectional study was conducted at The Aga Khan University Hospital, Karachi, Pakistan, after obtaining approval from the departmental Review Committee (ERC number: 2022-7188-20634). The duration of the study was from March 2022 to 2023.

All consecutive patients aged 18-80 years who underwent PCNL with preoperative haemoglobin of greater than 10 gm/dl were included. Exclusion criteria were patients on antiplatelets or anticoagulants, preoperative haemoglobin of less than 10 g/dl, those who required blood transfusion preoperatively, who underwent additional simultaneous urological procedures, or bilateral PCNL, those with skeletal deformities, and those with a CKD Stage of 3A or > (GFR of 45 or <). Patients with CT KUB from outside the study centre were also excluded from the study.

Following a detailed medical history, physical examination, and laboratory workup, the eligibility of the patients was assessed. Demographic data, including age, gender, comorbidities, height, weight, and BMI, were recorded before the surgery. S.T.O.N.E score (stone size, tract length, obstruction degree, number of calyces involved by the stone, essence) parameters were calculated on CT KUB on a 640-slice scanner using 3-mm axial and reformatted 3-mm coronal sections, including stone size in two dimensions using the longest diameter (mm^2), tract length or skin to stone distance (SSD) was calculated by measuring three distances from skin-to-stone at 0°, 45°, and 90° using radiological callipers, and the average of these values was used to represent SSD for each stone, degree of obstruction was determined on hydronephrosis severity, number of calyces involved by the stone, and essence means Hounsfield unit (<950 or >950).

Patient-related factors were also recorded, including comorbidity status, positive urine culture, preoperative haemoglobin, serum creatinine, and electrolyte levels. Operative factors like laterality, intraoperative time, Amplatz™ sheath size, puncture site, number of punctures, stone clearance, and need for stent placement were recorded. The STONE score of each patient was calculated by the primary investigator. The blood products were ordered preoperatively, as per institutional practice.

PCNL was performed in a prone position under general anaesthesia, and the tract was dilated using serial metallic dilators. Stone fragmentation was done with an ultrasonic probe using EMS™ or Lithoclast® Master (EMS, Nyon, Switzerland). At the end of the procedure, a 12 Fr. Foleys balloon inflated (2cc) or a 12 Fr. Nelaton™ catheter was placed as a nephrostomy tube at the discretion of the operating surgeon. Postoperatively, all patients had been tested for haemoglobin, haematocrit, and creatinine levels on the first postoperative day. The need for transfusion was, according to the surgeon's judgement, mainly based on intraoperative blood loss and a significant postoperative haemoglobin drop. Patients were discharged by the second or third postoperative day after the removal of nephrostomy tube. The primary outcome of the study was to assess if the STONE score is a predictive factor for blood transfusion, the secondary outcome was to determine if patient-related factors can predict the need for transfusion. The sample size was calculated on PASS™ sample size software version 22.

Data were analysed using SPSS™ statistics version 26 (IBM, Armonk, NY). Continuous variables such as age, body mass index (BMI), preoperative creatinine, number of punctures, intraoperative time, size of Amplatz sheath, and STONE score were described in terms of mean/median and standard deviation. Categorical variables such as gender, positive urine culture, rate of blood transfusion, and presence of comorbidities were described in terms of frequencies and percentages. The normality of the data distribution was checked through a Q-Q plot. The Chi-square or Fisher's exact test was applied to check the association between the dependent variable (blood transfusion) and independent variables. A p-value of <0.05 was taken as significant, with a confidence interval of 95%. Univariate and multivariate analyses were done, and logistic regression analysis was applied to compare the variables responsible for the outcome.

RESULTS

During the study period, 150 patients underwent PCNL. After the eligibility assessment, 89 patients were included in the study. Most of the patients were obese, and around two-thirds had at least one comorbid condition. Most of the patients had a stone volume of up to 399 mm^2, a tract length of >100 mm, and mild or no hydronephrosis. The mean STONE score was 7.87, with more than two-thirds of patients having a STONE score of less than 9 (Table I).

Table I: STONE score variables in the study population.

Variables	No. of patients	Mean (± SD) or %
STONE score		7.87 (1.70)
Stone size (mm)		
0-399	48	53.9%
400-799	24	27.0%
800-1599	17	19.1%
>1600	0	0
Tract length (mm)		
<100	8	9%
>100	81	91%
Obstruction		
No or mild hydronephrosis	68	76.4%
Moderate/Severe hydronephrosis	21	23.6%
Number of calyces involved		
1-2 Calyx	68	76.4%
>2	3	3.4%
Complete staghorn	18	20.2%
Essence (HU)		
<950	35	39.3%
>950	54	60.7%

Most of the access tracts (79.8%) were through the lower pole, and 7 patients (7.8%) required multiple tracts. Postoperative double J (DJ) stents were placed in 36 (40.5%) patients. The mean preoperative and postoperative haemoglobin were 12.87 mg/dl and 11.58 mg/dl, respectively. The total number of trans-

fusions was 8 (8.9%). All the patients who required transfusions had a postoperative haemoglobin drop of greater than 1 g/dl. None of the patients underwent angioembolisation or required an intraoperative transfusion (Table II).

Table II: Basic demographics and distribution of patient related and intra-operative factors.

Parameters	Frequencies	Mean (± SD and percentages)
Age (in years)		44.4(14.57)
Gender		
Male	59	66.30%
Female	30	33.70%
Comorbidities		
Ischaemic heart disease	3	3.40%
Diabetes	21	23.60%
Hypertension	41	46.10%
Positive urine culture	11	12.40%
BMI		
Underweight	6	6.70%
Normal	12	13.50%
Overweight	71	79.80%
Side of surgery		
Right	54	60.70%
Left	35	39.30%
Hospital stays		2.62 (0.84)
Preoperative creatinine		1.17 (0.88)
Postoperative stent placement	36	40.4
Duration of surgery		1.89 (0.61)
Preoperative haemoglobin		12.87 (1.75)
Postoperative haemoglobin		11.58 (1.83)
Number of transfusions		8 (8.9%)
Number of angioembolisation		0
Number of punctures		
Single	82	92.1
Double	7	7.9
Puncture site		
Lower calyx	71	79.8
Middle calyx	16	18
Upper calyx	2	2.2

Among factors related to blood transfusion, BMI and STONE score were found to be significant factors. Four out of eight patients requiring transfusion had a BMI of >25 (p = 0.02), and both STONE score groups had an equal number of transfusions, which was found to be a significant factor with a p-value of 0.03. Four patients requiring transfusion had a staghorn stone (p = 0.08) with a STONE score of >9 (Table III).

A linear regression model was applied for univariate and multivariate analyses. On univariate analysis, both BMI and STONE scores were found to be significant predictors of blood transfusion, with p-values of 0.04 and 0.05, respectively. On multivariate analysis, only BMI was found to be contributing to the preoperative factor for blood transfusion, with a p-value of 0.05 (Table IV).

The indication for transfusion in all patients was a significant Hb drop. However, the need for transfusion was decided based on the clinical judgement of the primary surgeon. Among patients requiring transfusion, one patient had postoperative sepsis, requiring a special care stay, and one patient had a history of PCNL on the same side in the past.

DISCUSSION

The goal of PCNL is to achieve complete stone clearance with the lowest possible risk of morbidity.[13] Similar to any other surgical intervention, PCNL is not without complications, and one of the most serious complications of PCNL is renal parenchymal haemorrhage, which can be manifested as haematuria or a marked haemoglobin drop. Bleeding can occur during puncture, instrument manipulation, and stone fragmentation secondary to parenchymal injury, but in majority of the cases it is due to the injury in interlobar and segmental renal vessels.[4] Although rare, the complication can pose a threat to both organ function and life. This necessitates adequate preoperative planning as well as the use of an objective assessment tool is imperative.

Various scores have been proposed to predict post-PCNL complications, these scoring systems include STONE score, Guy score, and CROES nomogram. These are simple and easily reproducible systems to classify stone complexity.[14] None of the scoring systems is superior to the other. The rationale for using STONE score in this study is that it is the most used scoring system at this institute. The STONE scoring system can predict stone complexity preoperatively, stone-free status and complications postoperatively.[15]

Shoaib *et al*. showed that there is a significant correlation between the STONE score and haemoglobin drop (p=0.05).[12] It has been previously shown by Okhunov *et al.* that the STONE score has a significant association with estimated blood loss during PCNL.[16] Other studies have failed to find significant associations.

The objective of this prospective single-centric study is to determine if the STONE score may be used as a predictor of postprocedure blood transfusion, patients were divided into two groups, one with STONE score of 6-9 and the other with a score of 10-12. A significant association was found between the score groups and the requirement for postprocedure transfusion; however, multivariate analysis failed to support such a significant association.

One of the patient-related factors that were studied in this study was obesity. BMI had a significant association with transfusion (p=0.028). Four patients with a BMI in the obese category needed a blood transfusion. Interestingly, most of the previous studies have not found this to be a significant association[8,17] except one study which supports the result of this study.[7] This hypothesises that body habitus directly complicates access and may compromise the choice of puncture site, making it suboptimal and consequently increasing the complication rates.

The relationship between underlying disease and increased bleeding during PCNL remains a controversial subject. Previous large-scale work has[18] not shown comorbidities to be significant predictors.

Table III: Association of STONE score with patient related and STONE related factors.

Patient-related factors	Total = 89	Not transfused = 81	Transfused = 8	p-value
DM	21 (23.5%)	18 (20.2%)	3 (3.3%)	0.386
HTN	41 (46.0%)	37 (41.5%)	4 (4.4%)	0.815
IHD	3 (3.3%)	3 (3.3%)	0	0.58
UCS +ve	11 (12.3%)	10 (11.2%)	1 (1.1%)	0.99
BMI				
Normal	18 (20.2%)	14 (15.7%)	4 (4.4%)	
Overweight/obese	71 (79.7%)	67 (75.2%)	4 (4.4%)	0.028
Stone-related factors				
Size (mm)				
0-399	48 (53.9%)	44 (49.4%)	4 (4.4%)	0.322
400-799	24 (26.9%)	23 (25.8%)	1 (1.1%)	
800-1599	17 (19.1%)	14 (15.7%)	3 (3.3%)	
Hounsfield unit (HU)				
<950	35 (39.3%)	33 (37.07%)	2 (2.24%)	
>950	54 (60.6%)	48 (87.6%)	6 (6.67%)	0.385
Tract length (mm)				
<100	8 (8.9%)	7 (7.86%)	1 (1.1%)	0.716
>100	81 (91.0%)	74 (83.1%)	7 (7.86%)	
STONE score				
6-9	70 (78.6%)	66 (74.15%)	4 (4.4%)	0.038
10-12	19 (21.3%)	15 (16.8%)	4 (4.4%)	
Hydronephrosis				
Mild	68 (76.4%)	62 (69.6%)	6 (6.74%)	0.922
Moderate/severe	21 (23.5%)	19 (21.3%)	2 (2.2%)	
Calyces involved				
1-2	68 (76.4%)	64 (71.9%)	4 (4.4%)	
3	3 (3.3%)	3 (3.3%)	0	
Staghorn	18 (20.2%)	14 (15.7%)	4 (4.4%)	0.084

The association of blood transfusion with patient-related and STONE-related factors were checked through Chi-square test.

Table IV: Univariate and multivariate analysis.

	B	S.E.	Wald	df	Sig.	Exp (B)
Univariate analysis						
STONE	-1.482	0.763	3.773	1	0.05	0.227
Pre Hb	-0.352	0.214	2.695	1	0.101	0.703
DM	-0.742	0.778	0.910	1	0.340	0.476
BMI	1.566	0.766	4.180	1	0.041	4.786
UCS	0.014	1.121	0.000	1	0.990	1.014
HTN	0.173	0.741	0.055	1	0.815	1.189
IHD	-18.926	23205.422	0.000	1	0.999	0.000
Multivariate analysis						
DM	-0.610	1.010	0.365	1	0.546	0.543
HTN	-0.328	1.028	0.102	1	0.750	0.721
IHD	20.743	21342.822	0.000	1	0.999	1020027224.080
UCS positive	0.625	1.338	0.218	1	0.640	1.868
Preop Haemoglobin	-0.320	0.273	1.381	1	0.240	0.726
STONE	0.994	0.867	1.313	1	0.252	2.701
BMI	1.793	0.901	3.960	1	0.047	6.006
Constant	-20.921	21342.822	0.000	1	0.999	0.000

This study did not find a significant association between diabetes mellitus, hypertension, ischaemic heart disease, and blood transfusion in patients undergoing PCNL. It was early demonstrated that high stone burden, staghorn calculi, the need for multiple punctures, and longer operative times are predictive determinants of blood transfusion requirements,[8,19,20] and this association was also found in this study. Among the eight patients who had transfusion, four had staghorn stones.

This study is limited by the fact that the sample size was small (n = 89), and the transfusion rate was below 10%. Patients who were predisposed to bleeding were excluded, including those on anticoagulation or antiplatelets, and those with metabolic conditions such as chronic kidney disease (CKD) that could contribute to bleeding diathesis. Doing so restricts the generalisability of the results and precludes their use to make guidelines applicable to all patient population.

In this series, only preoperative factors were assessed including patient-related factors and stone complexity, based on the STONE score to predict its association with the preoperative blood arrangement, and only these factors can help in guiding the preoperative decision of blood arrangement. This association of blood transfusion with the STONE score had never studied before. There are certain limitations of this study, one of the limitations is that the intraoperative

factors (e.g., operative time, Amplatz sheath size, etc.) were not included which could also play a significant role in postoperative haemoglobin drop and hence the blood transfusion, but surely it is also strongly linked with STONE complexity and certain preoperative factors. Another limitation includes a small sample size and single-centric study. Studies with larger sample sizes are needed to further confirm the observations of this study.

CONCLUSION

There is a significant association between BMI and STONE score and the postoperative need for blood transfusion. Therefore, blood product arrangements should be limited to obese patients and patients with complex stones.

ETHICAL APPROVAL:
This study was performed after obtaining approval from the Ethical Review Committee of Aga Khan University Hospital, Karachi (ERC No. 2022-7188-20634, Dated: 01-March-2022).

PATIENTS' CONSENT:
This was a cross-sectional descriptive study with no direct contact with patients and no change in management plan of patients, hence requirement for consent was exempted by ERC.

COMPETING INTEREST:
The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:
AS: Design of the work, acquisition, analysis and interpretation of data, and manuscript writing.
WA: Data analysis and result writing.
APH: Discussion writing.
HA: Proofreading and reviewing of the manuscript.
All authors approved the final version of the manuscript to be published.

REFERENCES

1. Quhal F, Seitz C. Guideline of the guidelines: Urolithiasis. *Curr Opin Urol* 2021; **31(2)**:125-9. doi:10.1097/-MOU.00000 00000000855.
2. Fernstrom I, Johansson B. Percutaneous pyelolithotomy. A new extraction technique. *Scand J Urol Nephrol* 1976; **10(3)**:257-9. doi: 10.1080/21681805.1976.11882084.
3. Arora AM, Pawar PW, Tamhankar AS, Sawant AS, Mundhe ST, Patil SR. Predictors for severe hemorrhage requiring angioembolization post percutaneous nephrolithotomy: A single-center experience over 3 years. *Urol Ann* 2019; **11(2)**:180-6. doi: 10.4103/UA.UA_75_18.
4. Poudyal S. Current insights on haemorrhagic complications in percutaneous nephrolithotomy. *Asian J Urol* 2022; **9(1)**:81-93. doi: 10.1016/j.ajur.2021.05.007.
5. Irani D, Haghpanah A, Rasekhi A, Kamran H, Rahmanian M, Hosseini MM, *et al*. Predictive factors of delayed bleeding after percutaneous nephrolithotomy requiring angioembolization. *BJUI Compass* 2023; **5(1)**:76-83. doi: 10.1002/bco2. 272.
6. Loo UP, Yong CH, Teh GC. Predictive factors for percutaneous nephrolithotomy bleeding risks. *Asian J Urol* 2024; **11(1)**:105-9. doi: 10.1016/j.ajur.2022.02.003.
7. Mithani MH, Khan SA, Khalid SE, Majeed I, Awan AS, Mithani S. Predictive factors for intraoperative blood loss during percutaneous nephrolithotomy. *J Coll Physicians Surg Pak* 2018; **28(8)**:623-7. doi: 10.29271/jcpsp.2018. 08.623.
8. Ketsuwan C, Pimpanit N, Phengsalae Y, Leenanupunth C, Kongchareonsombat W, Sangkum P. Peri-operative factors affecting blood transfusion requirements during PCNL: A retrospective non-randomized study. *Res Rep Urol* 2020; **12**:279-85. doi: 10.2147/RRU.S261888.
9. He Q, Song Z, Wang X, Hou B, Hao Z. influencing factors of massive hemorrhage and high-grade renal vascular injury after PCNL: A retrospective comparative study. *Int J Clin Pract* 2023; **2023**:5521691. doi: 10.1155/2023/5521691.
10. Al Adl AM, Mohey A, Abdel Aal A, Abu-Elnasr HAF, El Karamany T, Noureldin YA. Percutaneous nephrolithotomy outcomes based on S.T.O.N.E., GUY, CROES, and S-ReSC scoring systems: The first prospective study. *J Endourol* 2020; **34(12)**:1223-8. doi: 10.1089/end.2019.0856.
11. Biswas K, Gupta SK, Tak GR, Ganpule AP, Sabnis RB, Desai MR. Comparison of STONE score, Guy's stone score and Clinical Research Office of the Endourological Society (CROES) score as predictive tools for percutaneous nephrolithotomy outcome: A prospective study. *BJU Int* 2020; **126(4)**:494-501. doi: 10.1111/bju.15130.
12. Shoaib M, Bangash M, Salam B, Ather MH. The correlation between STONE nephrolithometry score and hemoglobin drop in patients undergoing percutaneous nephrolithotomy. *Cureus* 2020; **12(11)**:e11430. doi: 10.7759/cureus. 11430.
13. Ketsuwan C. Kongchareonsombat W, Sangkum P, Kijvikai K, Sananmuang T, Leenanupunth C. Perioperative renal calculus factors affecting percutaneous nephrolithotomy outcomes. *Insight Urol* 2019; **40(2)**:01–8. http://he02.tci-thaijo.org/index.php/TJU/article/view/209875.
14. Haldar B, Sarkar D, Chatterjee S, Pal DK. A prospective comparative evaluation of preoperative stone scoring systems with respect to stone free rate and complications in percutaneous nephrolithotomy. *Urologia* 2023; **90(3)**:527-34. doi: 10.1177/03915603221141170.
15. Sigdel B, Shrestha S, Maskey P. Predicting the outcome of mini percutaneous nephrolithotomy using STONE nephrolithometry score-a single-center experience. *Urolithiasis* 2022; **51(1)**:14. doi: 10.1007/s00 240-022-01379-2.
16. Okhunov Z, Friedlander JI, George AK, Duty BD, Moreira DM, Srinivasan AK, *et al*. S.T.O.N.E. nephrolithometry: Novel surgical classification system for kidney calculi. *Urology* 2013; **81(6)**:1154-9. doi: 10.1016/j.urology. 2012.10.083.

17. Ferreira TAC, Dutra MMG, Vicentini FC, Szwarc M, Mota PKV, Eisner B, *et al.* Impact of obesity on outcomes of supine percutaneous nephrolithotomy. *J Endourol* 2020; **34(12)**:1219-22. doi: 10.1089/end.2020.0576.
18. Kukreja R, Desai M, Patel S, Bapat S, Desai M. Factors affecting blood loss during percutaneous nephrolithotomy: Prospective study. *J Endourol* 2004; **18(8)**:715-22. doi: 10.1089/end.2004.18.715.
19. Siddique AB, Yesmin F, Babul MS, Khan SI, Roy A, Chowdhury MH. Blood loss and need for transfusion in percutaneous nephrolithotomy. *Bangladesh J Urol* 2021; **24(2)**: 124-8. doi:10.3329/bju.v24i2.59482.
20. Gadzhiev N, Malkhasyan V, Akopyan G, Petrov S, Jefferson F, Okhunov Z. Percutaneous nephrolithotomy for staghorn calculi: Troubleshooting and managing complications. *Asian J Urol* 2020; **7(2)**:139-48. doi: 10.1016/j.ajur.2019.10.004.