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Validity S.T.O.N.E. nephrolithometry scoring to predict stone free status in kidney stone patients after percutaneous nephrolithotomy



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ABSTRACT

Background: Kidney stone still a health problem in the world. Today, the choice of therapeutic modality is also increasingly varied, percutaneous nephrolithotomy (PCNL) is still the first line for stone therapy with varying success rates, some high or low. Sometimes need additional measures such as extracorporeal shock wave lithotripsy (ESWL), retrograde intrarenal surgery (RIRS) for the rest stone and good preventive behaviour are needed. This can be influenced by several risk factors, a risk factor predictor is required to get a high stone free rate in patients after PCNL.

Methods: This research is a cross sectional retrospective study, we recorded 50 patients at the Medical Records Installation at Sanglah Education General Hospital in Denpasar since January 2018-November 2019 with kidney stones performed by PCNL, each patient will be calculated S.T.O.N.E Nephrolithometry score can be seen on CT Stonography and the presence or absence of stone after PCNL. The parameters of S.T.O.N.E Nephrolithometry

are size, tract obstruction, number of calyces, essence. And calculated the best cut off, sensitivity, specificity, negative predictive value, positive predictive value, and accuracy of the S.T.O.N.E Nephrolithometry score to predict stone free status after PCNL.

Results: The best cut off value in this study is <9, where patients with S.T.O.N.E Nephrolithometry score < 9 have a risk stone free after PCNL 25 (50%) patients, while the S.T.O.N.E Nephrolithometry score >9, has a risk of not being free and there are stones left 25 (50%) patients. S.T.O.N.E Nephrolithometry had % sensitivity 60.6%, specificity 70.6%, and 64 % accuracy in this study. Positive predictive value and negative predictive values were 80% and 48%.

Conclusion: from this study the S.T.O.N.E Nephrolithometry score sensitively predicts stone free status in kidney stone patients after PCNL and can be used as a tool to education the patient before PCNL and therapy.

Keywords: S.T.O.N.E Nephrolithometry score, PCNL, stone free status.

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INTRODUCTION

Kidney stone still a major health problem in the world. Research conducted at the Routine Clinic of Sanglah Hospital Laboratory Installation for 1 year, from January 2007 to December 2007 taken from the archive of laboratory examination results showed the number of 133 patients due to urinary stone disease, with males more dominant than females (4:1) and most found in the age range 46-60 years.¹⁻³ Today, the choice of therapeutic modality is also increasingly varied, Percutaneous Nephrolithotomy (PCNL) is still the first line for stone therapy with varying success rates, some high or low. Sometimes need an additional measures such as ESWL, RIRS for the rest stone and good preventive behaviour are needed. This can be influenced by several risk factors, a risk factor predictor is required to get a high stone free rate in patients after PCNL. Several scoring systems have been proposed to describe kidney stones, but none of these systems is widely adopted because of their complex designs.⁹

Thomas and friends purposed Guy's tone score based on stone complexity and pelvicaliceal anatomy from plain x-ray, USG, CT and IVP findings. These score does not include the size of the stone which is size is a predictor for success of the PCNL. The purpose of this scoring system is to facilitate adequate management of patients with kidney stone who were going undergo PCNL so they are able to predict the outcome, for better treatment decisions and increase the stone-free rate as the final goal.¹

In 2013, the S.T.O.N.E Nephrolithometry score, (size, tract length, obstruction, number of calices, Essence) published. Unlike the scoring system described earlier, the S.T.O.N.E Nephrolithometry score are easily calculated, do not require special software, and are derived from CT Stonography images which have the best sensitivity, easy to access and has a high accurate value.^{2,4,5} This score uses 5 preoperative characteristics that depend on the results of CT Stonography. The 5 factors are

abbreviated in the acronym “STONE”. Evaluation of the success of the operation was examined with plain x-ray, ultrasound or CT stonography for 2 weeks postoperatively and was declared successful if there were no remaining stones or clinically insignificant stone fragments <4 mm, non-obstructive, non-infectious, and asymptomatic during evaluation.¹²

Noureldin et al. conducted this research and stated that the S.T.O.N.E Nephrolithometry gives more accurate results in determining stone-free numbers than other scoring. In Indonesia itself, the score system is rarely used, especially for cases of urinary stones where this case is recurring and frequent.

Research on the validation of S.T.O.N.E Nephrolithometry score in predicting stone-free numbers with different geographic conditions, habits and risk factors, has never been done in Indonesia and in Indonesia also no one has gotten the best cut-off value from this score.

METHODS

This research is a cross sectional retrospective study, we recorded 50 patients at the Medical Records Installation at Sanglah Education General Hospital in Denpasar since January 2018-November 2019 with kidney stones performed by PCNL, each patient will be calculated S.T.O.N.E Nephrolithometry score can be seen on CT Stonography and the presence or absence of stone after PCNL. The parameters of S.T.O.N.E Nephrolithometry are size, tract obstruction, number of calyces, essence. And calculated the best cut off, sensitivity, specificity, negative predictive value, positive predictive value, and accuracy of the S.T.O.N.E Nephrolithometry score to predict stone free status after PCNL.

RESULTS

During the period January 2018-November 2019, there were patients with kidney stones who

Table 1 Characteristics of the research sample

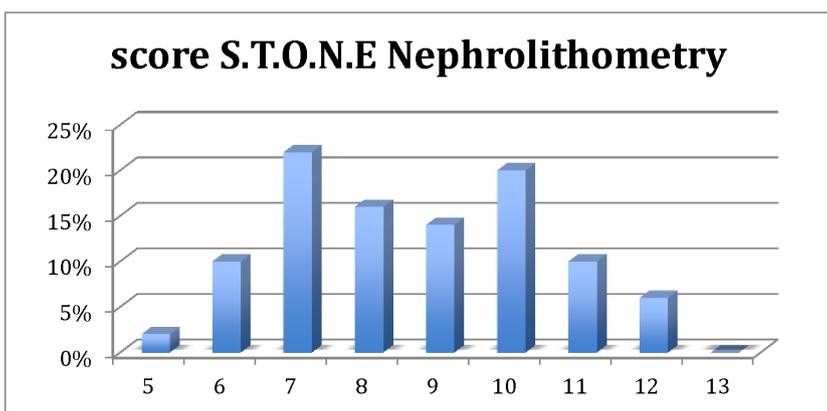
Variable	n=50
Age (years), Mean ± SD	53.1± 9.34
Min – Max	31-74
Sex	
Male	36 (72%)
Female	14 (28%)
BMI (kg/m²), median (IQR)	24.6 (8.4)
Min-Max	12.9 – 31.1
ASA score	
I	1 (2%)
II	28 (56%)
III	21 (42%)
IV	0
V	0
Comorbidities	
Cardiopulmonary	21 (42%)
Diabetes mellitus	9 (18%)
Renal failure	23 (46%)
Urinalysis (pre-op)	
Urine pH	
< 7	45 (90%)
7	1 (2%)
> 7	4 (8%)
Urine Concentration	
< 1.003	15 (30%)
1.003-1.035	35 (70%)
> 1.035	0

Table 1 *Continue*

Variable	n=50
Urine leukocytes [Large Visual Field (LVF)]	
0-5/LVF	7 (14%)
>5/ LVF	43 (86%)
Urine erythrocytes [Large Visual Field (LVF)]	
0-1/ LVF	6 (12%)
>1/ LVF	44 (88%)
Bacteria [Large Visual Field (LVF)]	
+1/ LVF	20 (40%)
+2/ LVF	10 (20%)
+3/ LVF	17 (34%)
+4/ LVF	3 (6%)
Painful kidney side	
Right side	19 (38%)
Left side	21 (42%)
Both side	10 (20%)
Location of the stone	
Calyx Superior	8 (16%)
Calyx Media	6 (12%)
Calyx Inferior	0
Calyx Superior, Media, Inferior	6 (12%)
Calyx Inferior,Pyelum	5 (10%)
Staghorn	25 (50%)
Duration of operation (minutes) median (IQR)	87.5 (185)
Min-Max	45 – 240
Length of stay (days) median (IQR)	5 (6)
Min-Max	3 – 17
Total postoperative bleeding (cc) median (IQR)	20 (80)
Min-Max	20 – 100
Surgical complication	
Without complication	45 (90%)
I	4 (8%)
II	1 (2%)
IIIA	0
IVA	0
Stone composition	
Oxalate	49 (98%)
Magnesium	13(26%)
Calcium	49 (98%)
Phosphate	34 (68%)
Cystine	1 (2%)
Uric Acid	28 (56%)
Ammonium	10 (20%)
Cholesterol	0
Carbonate	8 (16%)

Table 2 Characteristic S.T.O.N.E Nephrolithometry score

Variable	n=50
Stone size (S) (mm²)	
0-399	17 (34%)
400-799	16 (32%)
800-1599	12 (24%)
>1600	5 (10%)
Tract length (T) (mm)	
<100	40 (80%)
>100	10 (20%)
Obstruction (O)	
None	22 (44%)
Severe	28 (56%)
Number of calices (N)	
1-2	19 (38%)
3	6 (12%)
Staghorn	25 (50%)
Essence (E) (HU)	
< 950	19 (38%)
>950	31 (62%)
S.T.O.N.E Nephrolithometry score, rerata ± SB	
Operating results	8.6± 1.8
Stone Free	33 (66%)
Residual Stone	17 (34%)

**Figure 1** S.T.O.N.E Nephrolithometry score and total and percentage results

underwent CT Stonography who had undergone PCNL procedures, from the data obtained a sample of 50 patients who met the inclusion and exclusion criteria. A total of 36 (72%) samples were male and 14 (28%) samples were female. The age range of the sample ranged from 31 years to 74 years with an average age of 53 years (SD ± 9.34). The mean value of BMI in this study was 24, this shows the average patient under normal weight. With an average left side of 21 (42%) patients as a painful kidney side. Where 25 (50%) patients with the highest stone

location in calyx (minimum 2 calyx) and pyelum which we call staghorn stones and calyx superior which have significant numbers of residual stones. The average patients with ASA II status were 28 (56%) patients, with the most comorbidities were cardiopulmonary 21 (42%) patients, DM 9 (18%) patients, renal failure 23 (46%) patients, the results of the analysis urine showed the highest pH value <7 45 (90%) patients, most urine leukocytes > 5 / LPB as many as 43 (86%) patients, most urine erythrocytes > 1 / LVF as many as 44 (88%), bacteria + 1 / LVF as many as 20 (40%) patients. Post PCNL evaluation found 33 (66%) stone-free patients, from the results of stone analysis the highest content of oxalate 49 (98%), magnesium 13 (26%), calcium 49 (98%), phosphate 34 (68%), cystine 1 (2%), uric acid 28 (56%), ammonium 10 (20%), carbonate 8 (16%). The average duration of operation was 95.24 minutes, the length of stay was 6.18 days, total post-operative bleeding was 50.6 cc, with an average of no complications after surgery 45 (90%) patients. An illustration of the characteristics of the research sample can be seen in [Table 1](#).

Based on the S.T.O.N.E Nephrolithometry score, with a description of the sample stone size, stone distance to the skin, degree of obstruction, number of calyces involved, and stone density seen from CT stonography. The results of the assessment score in this study can be seen in [Table 2](#).

The description of the results of the S.T.O.N.E Nephrolithometry and the number and percentage of patients is depicted in a bar diagram as shown in [Figure 1](#). With the distribution of the highest number of patients there is a score 7 that is 22%. The lowest score is 5, which is 2% of the total stone-free patients. Whereas the highest score in this study (12) was obtained 6% of the total stone-free patients.

An illustration of the results of the STONE Nephrolithometry score, free of stones and stone residuals can be seen in [Figure 2](#). With a score 10 where there are 6 patients with stone residuals and at the lowest score value 5 there were no stone residuals and the highest score in this study was 12, still obtained stone residuals.

Based on the results of the analysis using the ROC curve showed that the ability of the S.T.O.N.E Nephrolithometry score in predicting stone-free status after PCNL was sufficient, that we can see in ROC value 0.3734 ([Figure 3](#)).

From 50 samples, the best cut off value in this study is < 9, where patients with S.T.O.N.E Nephrolithometry score < 9 have a risk stone free after PCNL 25 (50%) patients, while the S.T.O.N.E Nephrolithometry score ≥ 9, has a risk of not being free and there are stones left 25 (50%) patients. S.T.O.N.E Nephrolithometry had 60.6% sensitivity,

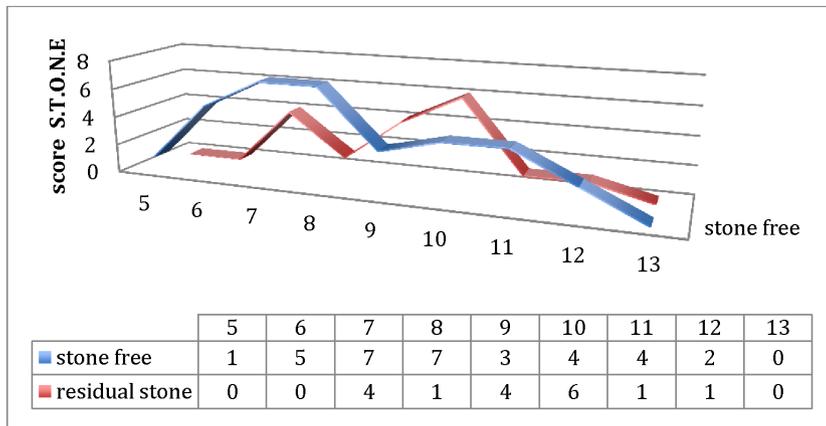


Figure 2 S.T.O.N.E Nephrolithometry score, stone free and stone residuals

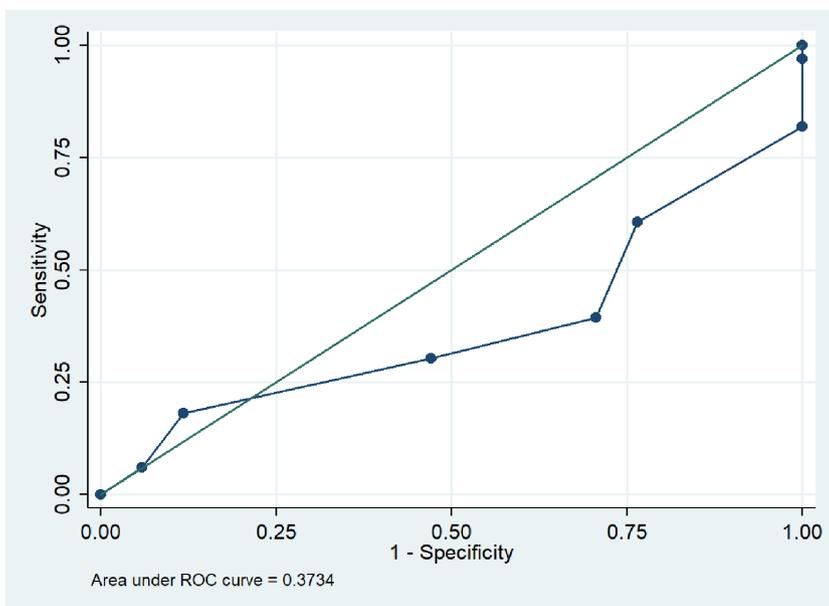


Figure 3 ROC graphs the ability of S.T.O.N.E Nephrolithometry to predict stone-free numbers after PCNL action (AUC: 0.373; SE: 0.079; 95% CI; AUC: 0.246-0.528)

specificity 70.6%, and 64 % accuracy in this study. Positive predictive value and negative predictive value with prevalence 66% were 80% and 48%.

DISCUSSION

Kidney stones need proper treatment to reduce the incidence and recurrence rate. Surgical treatment for kidney stones themselves has experienced a lot, from open surgery to the present time many have been replaced by minimally invasive procedures, such as PCNL, ESWL and RIRS. Since the stone removal procedure was first introduced through nephrostomy, PCNL has progressed even though ESWL and flexible urethroscopy is widely used in kidney stone therapy.¹¹⁻¹³

Based on the EAU guideline PCNL is the first choice of therapy for large, multiple and filling

lower pole stones.^{6,17,22} Therefore it is necessary to consider an accurate screening method in the initial identification, measurement of high-risk patients that have an impact on adequate perioperative management and ultimately can increase stone-free rates after PCNL which is also the goal of PCNL and also optimal care. Providing education to families can be given early through this screening method.^{2,21} The S.T.O.N.E Nephrolithometry score for the first time introduced by Okunov et al. can serve as a means for early screening of patients with kidney stones for PCNL, regarding stone free status after PCNL.

In this study, the characteristics of the average sample age of 53.1 ± 9.34 years with a predominance of men 72% with the most complaints of left back pain 42%, this is consistent with the kidney stone theory that the age between 30-69 years is the most frequent and more frequent incidence 2 -3 times occur in men than women.⁷⁻¹⁰ Median BMI 24.6 included in the normal weight criteria. Patients with increased BMI correlate with the onset of kidney stones, because it excretes more oxalate, uric acid, sodium and phosphate, and also supersaturation of uric acid also increases along with increased BMI.^{14,15}

In our study, patients with comorbidities in the form of renal failure were 46%, cardiopulmonary 42% in the form of hypertension, type 2 diabetes, both those who had received therapy and those who were newly diagnosed. This is consistent with the theory that obesity, diabetes mellitus, hypertension are risk factors for stone formation and stone formation at risk in patients with hypertension and renal failure.^{5,15} The location of most kidney stones is in the calyx and pyelum which form 50% stag-horn stones. The most preoperative ASA II distribution is 56% and ASA III and ASA I, there is no ASA IV or ASA V because this surgical procedure is an elective surgery procedure prepared, so that the patient's condition is ready and optimal for surgery.

The ASA score itself presents a picture of the presence or absence of comorbidities from patients whose role is to determine the occurrence of postoperative mortality, supported by research conducted by Arenal et al. stated that the ASA score has a significant influence as a strong predictor of mortality. Urine analysis is the first step in diagnosing urinary tract stones, urine pH itself is a measure of urine hydrogen ion concentration, in this study obtained with a pH of <7 as much as 90% which indicates acidic urine pH. Acid type stones are stones that form in an acidic atmosphere at a pH of urine <7, including: uric acid stones, calcium oxalate, and cystine stones. Poor hydration status can cause crystalline formation or crystal growth that has previously been formed.^{14,18} In this study

obtained with a normal density of 70%. For leukocytes urine > 5/LVF as much as 86%, urine erythrocytes > 1/LVF as much as 88% and bacteria + 1 / LVF as much as 40%. In accordance with previous studies where an increase in leukocytes, erythrocytes and the presence of bacteria in the urine indicate a urinary tract infection which could be a risk factor for stone formation.¹⁶

In our study, the average duration of surgery was 45-240 minutes with varying degrees of difficulty of operation, one of which was bleeding at the time of puncture, 3-17 days of treatment duration in which patients with kidney problems that required dialysis and blood transfusion after PCNL, total postoperative bleeding was obtained 20-100 cc, where in the research Subekti et al. got the results of the operating time of less than 120 minutes as much as 70% in the PCNL prone position and 95% in the supine position. The duration of treatment is significantly shorter, the duration of treatment is also associated with complications during surgery, although only minor complications (CSS level 1) and the higher ASA level will increase the risk of complications which will increase the length of stay.^{11,12,19}

Bleeding in the PCNL procedure is usually caused by parenchymal tears during puncture, but a temporary nephrostomy is performed to stop the bleeding and to monitor bleeding.¹³ Complications of PCNL are divided into two caused by the access of the punches and the stone removal process. In general the level of PCNL complications varies from 0-80% and complications because PCNL is difficult to compare so the CROES-Clavien System (CCS) system is also divided into two complications namely minor complications consisting of CCS levels 1 and 2, major complications consisting of CCS levels 3 and 4.⁷

From our research data, there were 4 (8%) patients with fever complications without the need for antibiotic replacement and 1 (2%) patients with bleeding who needed transfusion, this was due to kidney stones themselves as a source of infection, and bleeding was also a dreaded PCNL complication. thus the puncture is always directed through the posterior calyx to avoid the hypervascularisation region leading to the infundibulum.¹⁷ Analysis of stones obtained the most constituent components are calcium 49 (98%), oxalate 49 (98%) and phosphate 34 (68%), this is in accordance with research conducted previously by Hang et al. that the most common components are calcium oxalate and phosphate both single and combination.

Based on the S.T.O.N.E Nephrolithometry score consisting of stone size, tract length, obstruction, number of calyx involved, and essence density in this study the most stone size was 0-399 by 17

(34%) patients, the tract length <100 mm as many as 40 (80%) patients, the degree of obstruction was with severe hydronephrosis as many as 28 (56%) patients, the number of calyces involved was 25 (50%) staghorn patients with the highest stone essence density was > 950 ie 31 (61%) patient. With the results of the operation declared stone free as many as 33 (66%) patients and with residual stone 27 (34%) patients. This research has similarity with research conducted by Putri et al. with studies prospective observational analytic conducted in Surabaya, obtained results with an average stone size of 781 mm with the most stone distance to the skin is <100.

As well as research by Pradeepkumar at Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai with the degree of obstruction involved was 111 patients with severe hydronephrosis, the number of calyces involved, namely staghorn, and with the highest density > 950. In their research they concluded that this score was simple and effective in determining opportunities to achieve stone-free status with a PCNL session. total score, stone size and number of calyces involved were the most important predictors of success after PCNL.

The optimal cut-off value on the S.T.O.N.E Nephrolithometry score in this study to predict stone free status after PCNL was <9 (AUC 0.3734). It can be said that patients with a S.T.O.N.E Nephrolithometry score <9 (5-8) have a high-risk factor free of stones, whereas stone free in this study with prevalence 66% reached 80%, whereas with a S.T.O.N.E Nephrolithometry score >9 (9-13) had a low-risk factor for achieving stone free status were in this study obtained 48% residual stone after PCNL. From research conducted by Yurimoglu et al. they received a ROC analysis of this score of 7.5 with a sensitivity of 66.5% and specificity of 58%.

In addition, the accuracy of the S.T.O.N.E Nephrolithometry score in this study reached 64%, so this study was quite accurate even though it does not provide significant results in determining stone-free status. Because each parameter is derived directly from CT Stonography, the S.T.O.N.E Nephrolithometry score appears to be simultaneously accurate in stone-free rate (SFR) determination and is practical for clinical integration because it does not require software or specialised personnel. In a study conducted by Huynh et al. they compared between all nephrolithometric scores to obtain surgical planning, counselling to patients and the expected end result of free stone. It is said the optimal nomogram must have high predictive ability, practical and can be applied easily to kidney

stones. While the current data is not enough to conclude which rating system can be used as a golden standard, the S.T.O.N.E Nephrolithometry score itself has weaknesses, in the study of Taily et al. Stated in the ROC curve, the total S.T.O.N.E Nephrolithometry score does not appear to perform better, so that it requires further evaluation in another report. In 2015, Akhavi et al. conducted a retrospective analysis of 122 patients (76% SFR) and confirmed predictability and reproducibility. By stratification of stone by CT postoperative stonography 2, 2-4, and > 4 mm, they determined that the average S.T.O.N.E Nephrolithometry score was inversely correlated with SFR and for each increase in single-unit score, the stone-free probability decreased by 40-47% (depending on the definition used for SFR).

In particular, the use of post-treatment CT in this group may have reduced the reported SFR, because detection of small residual stones is more likely compared to plain photo and ultrasonography. Coupled with conditions in geography, climate, fluid intake, food, genetics, gender, occupation and age so that it can create significant results variations.¹⁵ Regarding overall complication rates, several studies have found significant correlations, a multi-institutional study by Taily and Labadie and a study by Noureldine, which however does not confirm the relationship in estimates of blood loss, operating time and length of stay.

This study has limitations, such as the boundaries for the length of tract length and the stone density evaluated are unclear, the definition of calyx and the imaging field are not standardised, the size of the stone/number of calyx involved is not standardized and the variable between the degree of hydronephrosis is subjective, according to research conducted by Huynh. Postoperation evaluation to declare stone-free only uses ultrasound where the ultrasound is less specific than CT stonography.

The PCNL procedure in this study was carried out by 4 Urologists, with different levels of expertise in performing surgery. Whereas PCNL's own actions are very dependent on the skill level of each operator. Because the research time is quite short with a minimum number of samples, this study does not conduct an evaluation of the operator's actions. De la Rosette et al. estimate that a doctor must perform around 24 PCNL to achieve proficiency, while competence is not achieved if experience has not reached 60 cases, and excellence is not obtained if not more than 200 cases have been carried out.²⁰⁻²² Although a retrospective chart review is only one arrow in health care, deficiencies in retrospective

research can be used to improve quality in service delivery, therapy, and action education.⁸

CONCLUSION

The S.T.O.N.E Nephrolithometry score sensitively predicts stone free status in kidney stone patients after PCNL and can be used as a tool to education the patient before PCNL and therapy.

ETHICAL CLEARANCE

All of study procedure has been approved by Committee of Ethic Faculty of Medicine, Universitas Udayana/Sanglah General Hospital with ethical clearance reference number LB.02.01/XIV.2.2.1/32624/2019.

CONFLICT OF INTEREST

Author declares there is no conflict of interest.

FUNDING

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