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Utility of POPVESL scoring system in the management of renal pseudoaneurysm: a retrospective study

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Abstract

Background We intended to assess the role of POPVESL scoring system in managing renal pseudoaneurysm at our institute which is a referral center in this region.

Methods We retrospectively reviewed the records of all patients who were managed for renal pseudoaneurysm between January 2020 and December 2022. Data were collected from patient medical records and analyzed by using SPSS Statistics for Windows version 29.0. Data were expressed as mean ± standard deviation (SD) or median for continuous variables, whereas frequency and percentage were used to express qualitative data. Demographic data, type of procedure, operative data, post-procedure data of patients, management type, i.e., conservative or angioembolization were recorded and POPVESL score of individual patients was calculated. Data analysis was conducted among subgroups based on management type, i.e., conservative vs angioembolization. ROC curves were utilized to find the threshold value for predicting the need of angioembolization.

Results Out of 55, pseudoaneurysm develops after USG guided PCN in 4 individuals, i.e., 7.3%; renal biopsy in 11, i.e., 20% and PCNL in 40, i.e., 72.7%. On statistical analysis, hemoglobin drop, number of PCV transfused, size of vascular lesion and interval of readmission showed significant differences among subgroups and were predictive of the need for angioembolization. There was a significant difference in POPVESL score between both subgroups. POPVESL score 11 and above is 100% specific and 90% sensitive for angioembolization.

Conclusion Renal pseudoaneurysm with a low POPVESL (i.e., < 11) score can be managed conservatively. This scoring system has the potential to help in making bedside decision for managing intrarenal vascular bleeding.

Keywords Pseudoaneurysm, Angioembolization, Conservative management, POPVESL score, Percutaneous nephrolithotomy

1 Background

A renal pseudoaneurysm is a rare but serious complication seen after procedures performed on the kidney, such as PCNL (percutaneous nephrolithotomy), renal biopsy, PCN (percutaneous nephrostomy), and partial nephrectomy. This life-threatening complication deserves meticulous care and treatment. It usually manifests in less than 1% of cases as delayed bleeding, within 3 weeks of intervention in the form of hematuria or retroperitoneal hematoma [1, 2]. Selective renal artery embolization is considered as the gold standard for management of renal pseudoaneurysm [3–5]. It is minimally invasive, precisely blocks the bleeding vessel and avoids the more morbid procedure of nephrectomy.

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Table 1 POPVESL score

P	Pseudoaneurysm	3 points
O	Open surgery on same kidney	5 points
P	Post-procedure interval (> 8.5 days)	2 points
V	Vascular lesion diameter (> 7.5 mm)	3 points
E	Extra unit of blood beyond initial stabilization	2 point per unit

Hemodynamically stable patients with renal pseudoaneurysms can be managed conservatively. Studies have shown that renal artery embolization is overused in the management of pseudoaneurysms, with most surgeons having a low threshold for embolization fearing unexpected bleeding and the need for blood transfusions [6–8]. Bleeding tendency and spontaneous closure of a renal pseudoaneurysm can be predicted by various anatomical factors of vascular lesions and the physiological condition of patient. Recently, a scoring system represented by acronym POPVESL [9] (Table 1) was introduced for the management of such type of bleeding vascular lesions. This scoring system can predict the bleeding tendency or spontaneous closure of a pseudoaneurysm and guide about the conservative management of these vascular lesions. Furthermore, it will help to reduce the necessity for expensive angioembolization and facilitate the proper allocation of endovascular procedures.

We aim this study to define role of POPVESL scoring system for managing of renal pseudoaneurysm in our institute, which is a referral center in this region.

2 Methods

After obtaining approval from the institutional ethical committee and medical record department of our institution, we retrospectively reviewed the records of all patients who were managed for renal pseudoaneurysm between January 2020 and December 2022.

As our hospital is a high-volume tertiary care referral center, we included all patients presented with delayed bleeding regardless of whether primary intervention was performed at our center or outside. All patients presenting with delayed bleeding with pseudoaneurysms were admitted to the urology department. After initial resuscitation, patients were evaluated for renal bleeding by means of CT renal angiography. Patients with deranged renal function underwent hemodialysis after consulting nephrologist before undergoing the contrast study. The anatomy and number of vascular lesions were documented. Hemodynamically unstable patients and patients with persistent bleeding underwent urgent selective renal artery embolization to control bleeding. Hemodynamically stable patients diagnosed with intrarenal vascular lesions were managed conservatively with strict bed rest and serial monitoring of vital signs and hematocrit. Ancillary procedures like cystoscopic clot evacuation and DJ stenting/percutaneous, nephrostomy were done for patients with clot retention and hydronephrosis/pyonephrosis, respectively. PCU (packed cell unit) was transfused after primary stabilization to correct initial deficit, targeting Hb of 10 g/dl. Patients with persistent hematuria for more than 4 days and serial hematocrit drop after initial correction requiring more transfusions were scheduled for angioembolization. Shrinkage of vascular lesions was observed on follow-up color Doppler USG in those who responded to conservative management. Demographic, type of procedure, operative data, post-procedure data of patients, management type, i.e., conservative or angioembolization were recorded, and the POPVESL score of individual patients was calculated. Data analysis was conducted among subgroups based on management type, i.e., conservative vs angioembolization. In both subgroups, none of the individuals were on any anticoagulant within 5 days of surgery, and their coagulation panel was normal periprocedurally.

Statistical analysis was performed on IBM SPSS software 29, using Fisher's exact test and Chi- square test for categorical variables. Student's t test and Mann–Whitney tests were used for continuous parametric and nonparametric variables. Univariate analysis done to predict factors needed for angioembolization and to find any significant difference in POPVESL score among both groups, i.e., conservative and angioembolization. ROC curves were utilized to find the threshold value for predicting the need for angioembolization.

3 Results

After reviewing the records of patients between January 2020 and December 2022, it was found that a total 55 individuals were readmitted with delayed bleeding after discharge from hospital following different procedures as outlined in Table 2 and were subsequently diagnosed renal pseudoaneurysm.

Regarding management, as indicated in Table 3, fifteen out of 55 cases (27.27%) of renal pseudoaneurysm responded to conservative management and were

Table 2 Renal pseudoaneurysm incidence following different procedures

Procedure	Number of cases of renal pseudoaneurysm	Percentage (%)
USG-guided PCN	4	7.3
Renal Biopsy	11	20
PCNL	40	72.7

PCNL percutaneous nephrolithotomy; *PCN* percutaneous nephrostomy

Table 3 Management patterns of renal pseudoaneurysms and angioembolization needed across various procedures

Renal pseudoaneurysm management	
Conservative	15 patients (27.27%)
Angioembolization	40 patients (72.7%)
Second angioembolization	2 patients
Renal pseudoaneurysm requiring angioembolization in different procedures	
1) PCNL	36 patients (90%)
2) Renal biopsy	3 patients (27.2%)
3) USG guided PCN	1 patient (25%)

PCNL percutaneous nephrolithotomy; *PCN* percutaneous nephrostomy

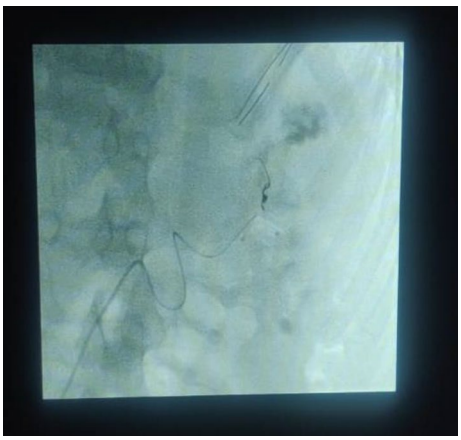

Fig. 1 Angioembolization of renal pseudoaneurysm

discharged once hematuria settled. These patients were advised to return in case of recurrent hematuria and were called a weekly basis follow-up to see the shrinkage of the vascular lesion on sonography. There was no recurrence of hematuria after conservative management, and shrinkage of the lesion was observed on follow-up color Doppler. Forty patients eventually required angioembolization as shown in Fig. 1. Among renal biopsy and PCNL patients, angioembolization was performed in 27.2% and 90%, respectively. Two patients required a second embolization after failure of first attempt. The final success rate for angioembolization was 100%. All individuals diagnosed with pseudoaneurysm on color Doppler were reconfirmed on contrast study like CT renal angiography or DSA, so specificity of color Doppler was reached to 100% when done by experienced radiologist. We did not replace DJ stent to prevent bleeding by tamponade effect.

Demographics in our study population, as mentioned in Table 4, indicated that males constituted 72.7% of the cases, while females accounted for 27.2%. Among comorbidities, 14.5% had CKD (GFR < 90 ml/min/1.73 m^2), 14.5% had diabetes, and 9.0% had hypertension. A history ipsilateral open renal surgery was present in 23.6% of patients, with pyelolithotomy being the most common procedure (21.8%) and one patient (1.8%) had a history of renal transplant. 5.5% cases had undergone for ESWL on same kidney and horse shoe kidney (abnormal anatomy) was observed in 1.8% of patients. On univariate analysis of demographic factors predicting the need

Table 4 Univariate analysis of demographic factors predicting the need for angioembolization

S. No	Demographic factors	Conservative ($n = 15$)	Angioembolization ($n = 40$)	*p* Value
1)	Age (mean ± S.D) (years)	45.1 ± 5.2	50.7 ± 9.2	0.137
2)	Sex (M: F) 40: 15 (72.7%: 27.2%)	5(33.33%):10(66.66%)	10(25%):30(75%)	0.735
3)	Diabetes 8 cases (14.5%)	2 (13%)	6 (15%)	1.000
4)	CKD 8 cases (14.5%)	4 (26.6%)	4 (10%)	0.193
5)	HTN 5 cases (9%)	2 (13.33%)	3 (7.5%)	0.605
6)	History of open surgery on same kidney (23.8%)			
6a)	Pyelolithotomy 12 cases (21.8%)	1 (6.6%)	11 (27.5%)	0.477
6b)	Renal transplantation 1 case (1.8%)	0	1 (2.5%)	1.000
7)	History of ESWL 3 cases (5.5%)	1 (6.6%)	2 (5%)	1.000
8)	Horse Shoe Kidney (Abnormal anatomy) 1 case (1.8%)	0	1 (2.5%)	1.000

M male; *F* female; *HTN* hypertension; *CKD* chronic kidney disease, glomerular filtration rate < 90 ml/min/1.73m^2; *ESWL* Extracorporeal shockwave lithotripsy; *SD* standard deviation)

for angioembolization, the comparison between the conservative and angioembolization groups showed no significant differences in age, sex, diabetes, CKD, HTN, history of open surgery on the same kidney, i.e., pyelolithotomy ($p=0.477$) and renal transplantation, history of ESWL and horse shoe kidney (abnormal anatomy).

All initial punctures to the kidney during all three procedures were performed using an 18-gauge needle. Furthermore, in all cases of USG-guided PCN, 12 Fr nephrostomy tubes were placed, and for PCNL patients, serial dilation up to 18 Fr was carried out to place an amplatz sheath. On examining the operative factors as detailed in Table 5, out of the 40 individuals who underwent PCNL, 21 (52.5%) had stones at a solitary location, i.e., renal pelvis or in one calyx, and 19 (47.5%) had stones at multiple locations, i.e., stones in ≥ 2 calyces or a staghorn calculus involving renal pelvis and multiple calyces. To achieve complete stone clearance, multiple access tracts were required in 16 cases (40%) where the renal system presented with stones in multiple locations, including staghorn stones or stones in two or more than two calyces. Among these cases, 10 individuals had a superior access tract, 2 individuals had a middle access tract, and 12 individuals had an inferior access tract. Nephrostomy tube was placed in 2 individuals. None of the interventions were abandoned because of bleeding.

On the analysis conducted to explore the association between operative factors during PCNL and the need for angioembolization ($p>0.05$), as presented in Table 5, no significant association was found for operative factors such as access through different calyces (inferior, middle, superior, or multiple calyces), stone location (solitary stone location or multiple locations), duration of surgery, and stone burden.

Results of the univariate analysis (Table 6), highlighting the post-procedural factors associated with the need for angioembolization of renal pseudoaneurysm. The factors evaluated include the interval of readmission, duration of second admission, size of vascular lesion, pre-admission Hb drop, and PCV unit transfusion. Significant differences were observed between the conservative and angioembolization groups for

Table 5 Univariate analysis of operative factors during PCNL predicting the need for angioembolization

S. No	Factor	Conservative ($n=4$)	Angioembolization ($n=36$)	*p* Value
1)	Access to renal stone through different calyx			
a)	Inferior calyx (12 cases)	1 (25%)	11 (30%)	1.00
b)	Middle calyx (2 cases)	1(25%)	1 (2.7%)	0.1923
c)	Superior calyx (10 cases)	0 (0%)	10 (27.7%)	0.5558
d)	Multiple calyx (16 cases)	2 (50%)	14 (38.8%)	1.00
2)	Stone location			
a)	Solitary stone location (21 cases) (Pelvic stone, stone in one calyx)	2 (1,1)	19 (11,8)	1.000
b)	More locations (19 cases) (Staghorn calculus involving renal pelvis and multiple calyces, stone in ≥ 2 calyces)	2 (1,1)	17 (10,7)	
3)	Duration of surgery (mean ± S.D.) (minutes)	52.5 ± 6.4	59 ± 16	0.396
4)	Stone burden (in mm) (median ± S.D)	24.72 ± 5.7	36.00 ± 9.9	0.123

S.D Standard deviation

Table 6 Univariate analysis of post-procedural factors predicting the need for angioembolization of renal pseudoaneurysm

S. No	Factor	Conservative (n = 15)	Angioembolization (n = 40)	P value
1)	Interval of readmission (in days) (median ± S.D)	4.0 ± 2.7	9.0 ± 2.2	< 0.001
2)	Duration of second admission (in days) (median ± S.D)	3.0 ± 1.3	6.0 ± 1.7	< 0.001
3)	Size of vascular lesion in mm (median ± S.D)	7.5 ± 0.81	10.5 ± 6.8	< 0.001
4)	Pre-admission Hb drop (mean ± S.D.)	3.8 ± 0.7	5.3 ± 1.05	0.258
5)	PCV unit transfusion (median ± S.D)	3.8 ± 0.578	5.2 ± 1.1	< 0.001

S.D Standard deviation, *PCV* Packed cell volume

all factors, except for pre-admission Hb drop. Notably, longer intervals of readmission, extended durations of second admission, larger vascular lesions, and increased PCV unit transfusion were significantly associated with the need for angioembolization ($p < 0.001$).

On comparison of management done in renal pseudoaneurysm across different procedures (Table 7). The results demonstrate that angioembolization was significantly more prevalent treatment option than conservative management in PCNL (90% vs. 10%, $p < 0.001$), while conservative approach was more common in renal biopsy (27.2% vs. 72.7%, $p < 0.001$). However, no significant difference was observed between conservative management and angioembolization in PCN (25% vs. 75%, $p = 0.057$).

The POPVESL scores (Table 8) in renal pseudoaneurysm were significantly higher in the angioembolization group compared to the conservative management group in whole study population, PCNL patients ($p < 0.001$), as well as in renal biopsy patients ($p = 0.012$).

ROC curve analysis was performed for POPVESL score to derive the cut-off point with optimal sensitivity and specificity, as shown in Fig. 2.

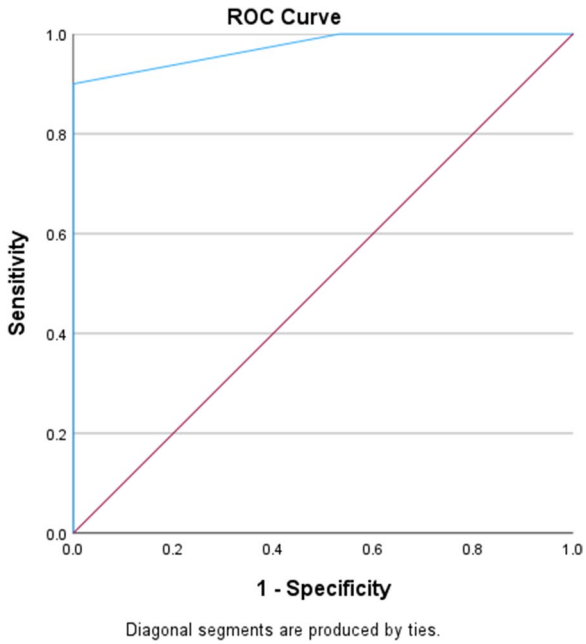

Fig. 2 ROC curve for angioembolization

Test result variable(s): POPVESL score	Coordinates of the Curve	
Positive if greater than or equal to[a]	Sensitivity	1 – Specificity
5.0000	1.000	1.000
6.5000	1.000	0.933
0.5000	1.000	0.867
8.5000	1.000	0.733
9.5000	1.000	0.533
11.0000	0.900	0.000
12.5000	0.450	0.000
13.5000	0.375	0.000
14.5000	0.225	0.000
16.0000	0.075	0.000
18.0000	0.000	0.000

The area under the curve is 0.973. The cut-off point with best sensitivity and specificity was 11 yielding 90% sensitivity and 100% specificity, indicating that a POPVESL score of 11 and above is 100% specific for angioembolization but 90% sensitive.

Table 7 Comparison between management done in renal pseudoaneurysm across different procedures

S. No	Factor	Conservative	Angioembolization	*p* Value
1)	PCNL	4 (10%)	36 (90%)	< 0.001
2)	PCN	3 (75%)	1 (25%)	0.057
3)	Renal biopsy	8 (72.7%)	3 (27.2%)	< 0.001

PCNL Percutaneous nephrolithotomy; *PCN* Percutaneous nephrostomy

4 Discussion

As our center is a high-volume tertiary care referral and academic center in India, performing over one thousand of PCNL every year, the incidence of intravascular lesion following PCNL is 1.6%, which is comparable to contemporary series [10, 11]. Despite 2 years of COVID-19, we had a total of 40 patients with pseudoaneurysms after PCNL over last 3 years, out of these 14 were referred from other centers. Twenty-two out of 2600 cases got

Table 8 Comparison of POPVESL scores in renal pseudoaneurysm between treatment groups

S. No	POPVESL score (Median ± S.D)	Conservative	Angioembolization	*p* Value
1)	a) In total cases	10.0 ± 1.2	12.0 ± 1.8	< 0.001
2)	b) Renal biopsy cases	8.5 ± 1.5	12.0 ± 0.5	0.012
3)	c) PCNL cases	9.5 ± 0.5	12.0 ± 1.9	< 0.001

angioembolized, which is 0.8% comparable to other studies [10, 11].

Renal pseudoaneurysm typically presents as flank pain, hematuria or unexplained anemia that can arise after injury to the renal artery or one of its branches through trauma, percutaneous kidney biopsy, endourologic procedures, partial nephrectomy, kidney transplantation or endovascular intervention. Considering the unpredictable clinical course of renal pseudoaneurysm treatment strategies must be individualized [12].

Management options based on the clinical course included a conservative approach for stable patients, urgent angioembolization for hemodynamically unstable patients, and elective intervention for those who did not respond to conservative treatment having prolonged hematuria, hematocrit drop and need of repeated transfusion. Early angioembolization has been suggested by some author to prevent blood transfusion [1].

Previous studies [6–8, 13] that searched for predictive factors of post-PCNL bleeding and success rate of angioembolization stated that the presence of stone burden, renal pelvis perforation, multiple tract access, history of open renal surgery of affected side, operation time, intraoperative bleeding, Hb drop, and need for transfusion were predictors of angioembolization. A recent study performed by Shadpour et al. [9] proposed POPVESL score to assist bedside decision for management of post-PCNL bleeding. Based on multivariate analysis of risk factors, calculated odds ratios, and expert opinions of researchers they proposed POPVESL score. In their study, POPVESL score below 11 was 100% specific and 81.6% sensitive in predicting success with medical management and above 16 was 100% specific and 52% sensitive for angioembolization.

In our study, we calculated POPVESL score for intrarenal vascular lesions caused by PCNL, PCN and renal biopsy. The scores demonstrated a significant difference among conservative and angioembolization groups in cases of PCNL, renal biopsy and overall cases. Vascular lesions caused by USG guided PCN and renal biopsy were managed conservatively in 75% and 72.7% cases, respectively. While angioembolization was required in 90% of vascular lesions caused by PCNL because complications of initial puncture were exacerbated by dilatation and maneuvering involved in clearing the kidney stones.

In our study, conservatively managed cases showed high success rate and a low complication rate. As we all know, angioembolization is a costly affair and has its potential complications. Due to increasing trend of using percutaneous renal procedure like PCNL, PCN, etc., there is an increased burden of intrarenal vascular complications. For developing countries like India, angioembolization for the management of renal pseudoaneurysms leads to an excessive economic burden on government hospitals, where patients are covered under the government insurance scheme. Therefore, POPVESL scoring system provides an option to assist bedside decision-making for the patients who can be managed conservatively.

Along with the retrospective nature of study, small sample size because of overall low incidence of this complication is a major limitation of this study. Another limitation is that we only considered pseudoaneurysm as an intra-renal vascular complication, of which 72.7% required angioembolization, while a previous study [9] reported 68.5% cases of renal arteriovenous fistula were managed conservatively. Therefore, further prospective studies with larger sample sizes are warranted to better define the utility of this score system.

5 Conclusion

A low POPVESL score of a renal pseudoaneurysm (i.e., < 11) can be managed conservatively. This scoring system has the potential to help in making bedside decisions for managing intrarenal vascular bleeding and updating its operational guidelines.

Abbreviations

M	Male
F	Female
HTN	Hypertension
CKD	Chronic kidney disease
ESWL	Extracorporeal shockwave lithotripsy
SD	Standard deviation
PCNL	Percutaneous nephrolithotomy
PCN	Percutaneous nephrostomy
DSA	Digital subtraction angiography
ROC	Receiver operating characteristics curve

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Author contributions

SS wrote the manuscript and contributed to research conception and design, acquisition, analysis and interpretation of the data. FMA and MKM help in data acquisition and analysis. SAP contributed to drafting of the article. MSW analyzed the results and supervised paper writing. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available because it could compromise individual privacy but can made available from corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Institutional ethical committee approval was obtained from IEC-SKIMS on 10.12.2022 with IEC number RP-143/2022. Because of retrospective nature of this study, the requirement for informed consent was waived.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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