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Complications after percutaneous nephrolithotomy: A single-centre experience

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Abstract
Percutaneous nephrolithotomy (PCNL) is the "gold standard" technique for managing of patients with kidney stones different sizes and intrarenal localization. During over than 30 years of PCNL use urologists tried to establish parameters and characteristics that are responsible for procedure complications that usually occurs in 20-83% of cases. The aim of our study was investigation of the predictive factors of PCNL complications development. We retrospectively analyzed our experience in the treatment of 2223 patients (pts) with kidney stones who were managed by PCNL at our clinic from 2008 till 2014 years. By using Charlson scale we calculated CCI for ever patient and afterwards divided all patients of 6 groups: group 1 (CCI = 0), group 2 (CCI = 1), group 3 (CCI = 2), group 4 (CCI = 3), group 5 (CCI = 4), group 6 (CCI = 5), group 7 (CCI > 5). The increasing of percutaneous tracts number, presence of renal calculi with GSS-3 and GSS-4 as well as total CCI score ≥3 in patients who underwent PCNL could be considered as prognostic factors of complications development.

Keywords: Percutaneous nephrolithotomy, complications

1. Introduction
Percutaneous nephrolithotomy (PCNL) is the "gold standard" technique for managing of patients with kidney stones different sizes and intrarenal localization. It involves minimally invasive surgery performed through a little incision in the skin overlying the ren [1]. During over than 30 years of PCNL use urologists tried to establish parameters and characteristics that are responsible for procedure complications that usually occurs in 20-83% of cases. There were pointed numerous predictive factors of PCNL complications such as stone size, burden and localization; presence of hydronephrosis etc. [2-4].
However, until recently each parameter predominantly was analyzed solitary and without communication with patient's comorbidity status as well as peculiarities of PCNL performing.
Till the present time there were published few papers that advocate or negate the validity of the Guy's stone score (GSS) and the Charlson Comorbidity Index (CCI) for prediction of PCNL outcomes [5]. A part of them is controversial and point on different conclusions [6-9]. According to some researchers CCI total score could be considered as predictive factor of PCNL complications rate. However, the concrete CCI score that is responsible for presence/absence of side-effects development is a question for discuss [7, 10, 11].

2. Objectives
We aimed to investigate the predictive factors of PCNL complications development.

3. Material and Methods
We retrospectively analyzed our experience in the treatment of 2223 patients (PTS) with kidney stones who were managed by PCNL at our clinic from 2008 till 2014 years. Inclusion criteria were the following: age over 18 y.o., informed content, diagnosed kidney stones that were treated by PCNL. For diagnosing and determining of intrarenal stone localization (GSS) we used ultrasound investigation and computerized tomography before operation. According Thomas K *et al*. we classified all renal calculi on 4 grades: grade I, solitary stone in mid/lower pole or solitary stone in the pelvis with simple anatomy; grade II, solitary stone in upper pole or multiple stones in a patient with simple anatomy or a solitary stone in a patient with abnormal anatomy; grade III, multiple stones in a patient with abnormal anatomy or stones in a caliceal diverticulum or partial staghorn calculus; grade IV, staghorn calculus or any stone in a patient with spina bifida or spinal injury [5].

During preoperative investigation we noted the patient's comorbidities that were necessary for CCI calculation. By using Charlson scale we calculated CCI for ever patient and afterwards divided all patients of 6 groups: group 1 (CCI = 0), group 2 (CCI = 1), group 3 (CCI = 2), group 4 (CCI = 3), group 5 (CCI = 4), group 6 (CCI = 5), group 7 (CCI > 5) [12].

For determination of complication severity in our patients we used modified classification by Clavien-Dindo [13].

All statistical analyzes were made by running SPSS for Windows (version 13.0) on a personal computer. Means (M), standard deviations (SD), ranges, and frequencies were used to describe the data. Box and whiskers plot showed the interquartile ranges, the medians and the extreme values. Data were analyzed by means of the one-way ANOVA; the linear trend and the simple contrast were applied. The linear by linear chi squared test was applied to discrete variables. Odds ratios (OR) for complications were calculated for preoperative risk factors and logistic regression analysis was used to assess the relevant risk factors. Two-tailed p values less than 0.05 were considered statistically significant [14].

4. Results

The mean operative time was 68,3±17,6 min (95% CI, range 28-210 min). Subcostal accesses were performed in 2139 (96.2%) cases, intercostal (10^{th}-12^{th}rib) – in 84 (3.8%) cases.

The majority of PCNLs (59.7%) was performed through one percutaneous tract and by subcostal access preferable. Two percutaneous tracts we performed in 31.2% cases, three – in 7.4%, four – in 1.7% cases and five – only in 0.04% cases.

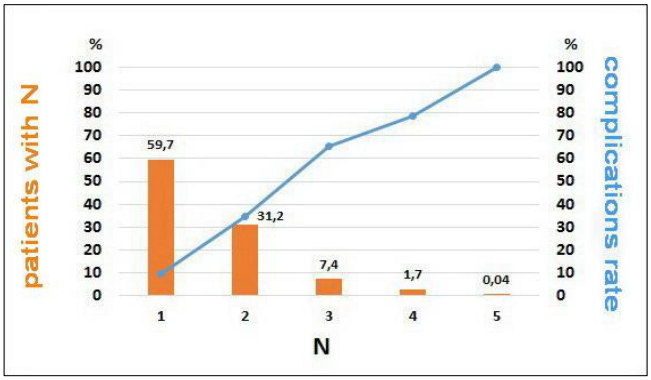
Table 1 presents the number of PCNL tracts and the rates of PCNL complications.

Table 1: The number of PCNL tracts and complication rates.

Number of percutaneous tracts	N	n	%	Complications rate		p
				n	%	
	1	1327	59.7	149	11.2	<0.05
	2	693	31.2	241	34.8	<0.05
	3	165	7.4	97	58.8	<0.05
	4	37	1.7	19	51.4	<0.05
	5	1	0.04	1	100	—
Overall		2223	100	507	100	—

N – number of percutaneous tracts

As Table 1 lists, the PCNL complication rate correlates with number of percutaneous tracts (Fig 1).



N – number of percutaneous tracts

Fig 1: The correlation of PCNL tracts number with complication rates

As presented at Fig 1, the increasing of PCNL tracts number leads to growing of complications rate. So, the number of PCNL tracts could be considered as prognostic factor of complications development.

Using the Clavien-Dindo classification we revealed that 507 (22.8%) out of 2223 (22.8%) patients had complications and 1716 (77.2%) pts had no complications. The postoperative mortality rate (grade V) was 0.1% (3 PTS). The 507 complicated patients had the following Clavien-Dindo grades: 178 patients (8.0%) patients had grade I, 174 (7.8%) had grade II, 145 (6.5%) had grade III, 7 (0.3%) had grade IV and 3 (0.1%) of them had grade V (Table 2).

Table 2: PCNL complications according Clavien-Dindo grading system.

Grade		Complication	n	%
I		Persistent fever	63	2.8
		Persistent pain in operated kidney	51	2.3
		Transient elevation of serum creatinine >10% compare to preoperative level	64	2.9
		Overall	178	8.0
II		Blood transfusion	49	2.2
		UTI	101	4.5
		Urine leakage < 12 h	19	0.9
		Ileus	2	0.1
		Pneumonia	2	0.1
		Transient ischemic attack	1	0.04
		Overall	174	7.8
III	IIIA	Paranephritis, kidney abscess, perinephric abscess	6	0.3
		Purulent drainage	5	0.2
		Pneumothorax/hydrothorax	5	0.2
		Cystoscopy and double J-stent placement	46	2.1
		Percutaneous nephrostomy	3	0.1
		Bowel perforation	1	0.04
		Overall	66	3.0
	IIIB	Ureterorenoscopy	15	0.7
		Cystoscopy and double J-stent placement	54	2.4
		Bowel perforation	1	0.04
		Bleeding requiring the renal artery embolization	9	0.4
		Overall	79	3.6
IV	IVA	Bleeding requiring the nephrectomy	5	0.2
	IVB	Urosepsis	2	0.1
V		Death	3	0.1
Overall			507	22.8

UTI – urinary tract infection that required additional antibacterial treatment except of prophylactic.

As Table 2 presents, overall complications rate in patients with kidney stones who were underwent PCNL was 22.8%. Among of all complicated cases the grade I Clavien-Dindo complications had the prevalence and occurred in 178 (8.0%) pts. The most widespread PCNL complication was urinary tract infection that required additional antibacterial treatment was noted in 101 (4.5%) cases. We also can summarize that PCNL complications rate grades I-II Clavien-Dindo were similar and occurred in 35.0% and 34.3% cases correspondingly (p>0,05). These grades of complications were registered in 69.3% cases totally that advocates the safety of PCNL performing for the kidney stones treatment. The frequency of PCNL complications graded IV-V according to Clavien-Dindo was only 2.0%.

For evaluation of the utility of the Guy's stone score in prediction of PCNL complications we compared the frequencies of complications depending on the GSS of patients. Table 3 lists the stratification of PCNL complications with corresponding GSS

Table 3: Stratification of PCNL complications correspondingly to GSS

Variables		n	GSS-1, n (%)	GSS-2, n (%)	GSS-3, n (%)	GSS-4, n (%)	p
Complications rate		507	46(9.1)	87(17.2)	213(42.0)	161(31.8)	<0.05
Clavien-Dindo grade	I	178	23(4.5)	43(8.5)	69(13.6)	43(8.5)	<0.05
	II	174	17(3.4)	33(6.5)	65(12.8)	59(11.6)	<0.05
	IIIA	66	4(0.8)	4(0.8)	32(6.3)	26(5.1)	<0.05
	IIIB	79	2(0.4)	5(1.0)	45(8.9)	27(5.3)	<0.05
	IVA	5		2(0.4)		3(0.6)	-
	IVB	2				2(0.4)	-
	V	3			2(0,4)	1(0.2)	-

As presented at the Table 3, we registered the correlation between the PCNL complications rate according to Clavien-Dindo scale and GSS in our patients. Increasing of GSS leads to growing of complications rate. Among of all 507 complicated cases in 46(9.1%) pts renal calculi were characterized by GSS-1, in 87(17.2%) pts – GSS-2, in 213(42.0%) pts – GSS-3, in 161(31.8) pts – GSS-4. In major part of complicated cases were diagnosed renal calculi with GSS-3 grade while severe complications (Clavien-Dindo III-V) predominantly were registered in patients with GSS 3-4 kidney stones.
The obtained results are presented at Fig. 2.

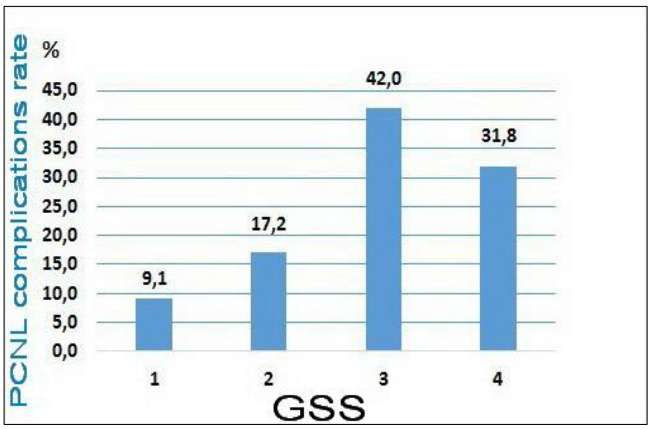


Fig 2: PCNL complications rates with GS scores.

As Fig. 2 shows, the major part of complicated cases presented by renal calculi with GSS-3 grade while severe complications (Clavien-Dindo III-V) predominantly were registered in patients with GSS 3-4 kidney stones.
Table 4 presents the logistic model for statistically significant GSS scores in PCNL complications development.

Table 4: Logistic model for prediction of PCNL complications development.

Variables	Coefficients	OR	95% CI	p
GSS-1	—	—	—	0.0004
GSS-2 ref GSS-1	0.4716	1.4271	1.0816 – 1.6835	>0.05
GSS-3 ref GSS-1	1.8624	4.2153	2.8761 – 7.3246	<0.05
GSS-4 ref GSS-1	1.6837	3.3461	1.9236 – 4.8372	<0.05

As presented at Table 4, the patient with GSS-2 had a 1.4271 times higher risk of PCNL complications opposed to the patient with GSS-1 (p>0.05 for 95% CI). At once the patient with GSS-3 and GSS-4 had a 4.2153 and 3.3461 times higher risks of complications over against the patient with GSS-1 respectively (p<0.05 in both comparing groups for 95% CI).

Thus, the Guy's stone score 3-4 could be considered a prognostic factor of PCNL complications development in patients with kidney stones.
For determining the validity of CCI in prediction of PCNL complications we collated the complications rates with CCI total scores in complicated cases. We developed the Table 5 that systemizes CCI scores and frequency of PCNL complications presence/absence.

Table 5: PCNL complications rates and corresponding CCI scores.

CCI	N (%)	PCNL complications		p
		Yes n (%)	No n (%)	
0	1584 (71.3)	314 (19.8)	1270(80.2)	<0.05
1	297 (13.4)	69(23.2)	228(76.8)	<0.05
2	172 (7.7)	41(23.8)	131(76.2)	<0.05
3	99 (4.5)	43(43.4)	56(56.6)	<0.05
4	52 (2.3)	29(55.8)	23(44.2)	<0.05
5	12 (0.5)	8(66.7)	4(33.3)	<0.05
>5	7 (0.3)	3(42.9)	4(57.1)	<0.05
Overall	2223 (100)	507 (22.8)	1716 (77.2)	<0,05

As Table 5 presents, there was registered the reverse correlation between CCI and PCNL complications rate in kidney stones patients. In cases with CCI = 0 complications occurred in 19.8% cases only, while the absence of complications was registered in 80.2% patients from this cohort (p<0.05).
The PCNL complication rates in patients that characterized by CCI 0, 1 and 2 points demonstrated no differences and were registered in 19.8%, 23.2% and 23.8% cases correspondingly (p>0.05). Obtained results show that probability of PCNL complications development in patients with kidney stones that characterized by CCI 0-2 is the similar.
Simultaneously the increasing of CCI ≥3 leads to significant increasing of PCNL complications rate. The complications rates in patients with CCI=3, 4, 5 and >5 points, were 43.4%, 55.8%, 66.7% and 42.9% correspondingly. So, the complications rate in patients with CCI = 3 was 43.4%, that was statistically meaningful compare to cohorts of patients with CCI = 0, 1 and 2 points (43.4% vs 19.8%, p<0.05; 43.4% vs 23.2%, p<0.05; 43.4% vs 23.8%, p<0.05; correspondingly).
Obtained results are presented at the Fig 3.

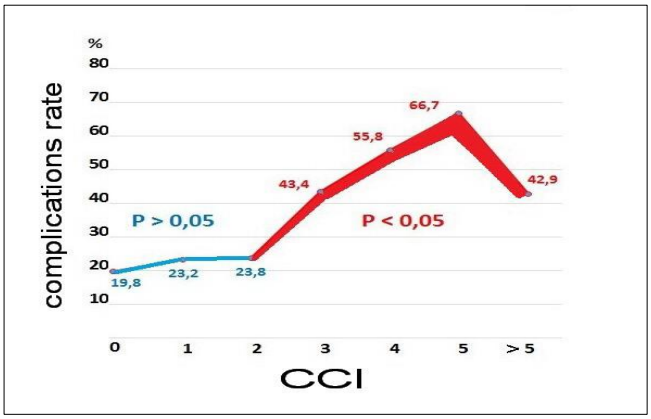


Fig 3: PCNL complication rates with correspondent CCI scores.

Table 6 presents the logistic model for statistically significant CCI scores in PCNL complications development.

Table 6: Logistic model for prediction of PCNL complications development.

Variables	Coefficients	OR	95% CI	p
CCI=0	—	—	—	0.0003
CCI=1 ref CCI=0	0.3428	1.1527	1.0320 – 1.7342	>0.05
CCI=2 ref CCI=0	0.4713	1.1861	1.0719 – 1.9325	>0.05
CCI=3 ref CCI=0	1.4826	2.2163	1.4115 – 3.8276	<0.05

As presented at Table 6, the patient with CCI = 1 and CCI = 2 had a 1.1527 times and 1.1861 times higher risks of PCNL complications opposed to the patient with CCI = 0 points respectively (p>0.05 in both comparing groups for 95% CI). At once the patient with CCI = 3 had a 2.2163 times higher risk of complications over against the patient with CCI = 0 points (95% CI: 1.4115 – 3.8276, p<0.05).

5. Discussion

The validation of approved scoring systems in prediction of PCNL complications is a topic for numerous contemporary investigations. A part of researchers advocated the utility of GSS for that aim, another are opposite.

Şükrü Kumsar *et al.* in 2015 concluded that Guy scoring systems may be used as effective instrument particularly for predicting perioperative and postoperative PCNL complications [9].

Tulga Eğilmez *et al.*, 2015, also considered about good correlation of the Guys's stone score with PCNL complications that can be used for pre-operative counseling and decision making. The overall complication rate of this study was 24%. Authors revealed that Guy's stone score grade 1 and 2 were associated with success and grade 3 and 4 were associated with complications [15].

Sinha R.K *et al.* in 2015 noted that the overall PCNL complication rate according to Clavien grading system was 40.1%. The final stone clearance rates were 93.9, 85.71, 90.47, and 77.77% in GSS I, II, III, and IV, respectively (p<0.001, <0.05, <0.05 and >0.05, respectively). Authors registered the Clavien complication rates of 23, 61, 52, and 77.7% in patients with GSS I, II, III, and IV, respectively (p<0.001). They concluded that GSS is a simple and easily reproducible system to preoperatively predict perioperative complication rate. In author's opinion, the GSS use helps in better preoperative counseling of PCNL patients [16].

Mandal S. *et al.*, 2012 find that all grades of PCNL complications were more common in patients with GSS III and IV (p<0.05). Researchers also noted that blood transfusion rates in PCNL patients varied in 3%, 15%, 72% and 100% of renal units with GSS I, II, III, and IV, respectively. In conclusion authors suggested that high transfusion rates in GSS III-IV were probably due to the fact that most of these patients were managed by multiple punctures and also needed re-look procedures [17].

Opposite to abovementioned researchers, Matlaga B.R. & Hyams ES in 2011 resumed that despite of its premise merits, the real validity of GSS for prediction of PCNL outcomes needs in future studies with involving of larger population of patients [6].

Our study that was based on 2223 pts demonstrates the correlation of PCNL complications with GSS thereby it advocates the utility of this scoring system further use for prediction of PCNL outcomes.

It looks that the number of percutaneous tracts also influence on PCNL complications development. We agree with Muslumanoglu AY *et al.*, 2006, that need for multiple access points and significantly increases complication rates [18].

CCI score could be considered as one else predictive factor of PCNL complications. Kathpalia R. in 2012 concluded that patients with higher CCI score had a significantly greater rate of postoperative risk of hemorrhage and medical complications, including death, than those with lower CCI [19].

Unsal a et colleagues in 2012 concluded that CCI ≥ 2 was significantly related to higher medical complication rates after PCNL. However an important limitation of that study was the little part (6.9%) of patients with CCI ≥ 2 in involved cohort. That is why obtained results cannot be generalized to settings with more serious comorbidities [7]. Unlike the abovementioned study the part of CCI ≥ 2 patients in our own research was 15.4% (342 pts). Our results demonstrate that CCI=2 could not be considered a risk factor for PCNL complications development compare to patients with CCI < 2, while CCI = 3 is a cut-off for increasing the risk. The complications rates in our patients with CCI=3, 4, 5 and >5 points were high with presentation in 43.4%, 55.8%, 66.7% and 42.9% cases correspondingly. Decreasing of complications rate in cases CCI > 5 compare to CCI 3-5 could be explained by tenuous representation of such patients in our cohort that was noted in 7 (0.3%) cases only.

Simultaneously, we registered relatively high complications rate in patients with CCI=0 which amounted to 19.8% cases with this sore. That fact demonstrates that absence of serious comorbidities does not guarantee the safety of PCNL over against patients with minor concomitant pathology.

We agree with Mirheydar H.S. *et al.* 2013 that concluded about validity of CCI scoring system in prediction of PCNL safety. According to researchers, the higher comorbidity (Charlson ≥3) was exactly the strongest predictor of PCNL complications in multivariate analysis (odds ratio=2.22, p<0.001) [20].

Finally, complicatons after PCNL should be kept to a minimum in experienced hands with the development of new technologies & techniques [21].

6. Conclusions

The increasing of percutaneous tracts number, presence of renal calculi with GSS-3 and GSS-4 as well as total CCI score ≥3 in patients who underwent PCNL could be considered as prognostic factors of complications development.

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