Complications associated with percutaneous nephrolitholapaxy (PCNL) - our experience and literature review

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INTRODUCTION

Percutaneous entry into the renal collecting system was routinely utilized for endoscopic treatment of nephrolithiasis in mid 1970's. Although PCNL has been initially proved to be an effective procedure, at the same time the concurrent ESWL has gain more popularity that resulted in marked decrease in the utilization of PCNL. Revival of this procedure in the beginning of 2000's is largely attributed to the increase in stone prevalence and to the limitations of newer ESWL equipment, as well as the improvement of PCNL indications, techniques and instrumentation. Today, PCNL is considered the standard treatment for staghorn and large-volume renal stones, stones refractory to other modalities, cystine and difficult lower pole stones, and stones in anatomically abnormal kidneys.

PCNL is safe procedure which is well tolerated, but as with any other surgical procedure, it is associated with a specific set of complications. There is a marked heterogeneity in reporting complication rates in literature, and this problem was highlighted in Ad Hoc EAU guidelines panel who recommended urgent creation of uniform and reproducible quality system. Modified Dindo-Clavien grading system today is the most utilized classification for complications in urology, and standard in reporting complications for PCNL.

To analyze the complication rate for PCNL using the modified Dindo-Clavien grading system in our patients and literature review. Methods: In our institution, with few breaks, PCNL was performed since mid 2010. Complication rate in 63 patients was analyzed retrospectively. Modified Dindo-Clavien grading system that is validated for PCNL has been accepted for classification of complication for PCNL, and literature review was performed. We have summarized the most significant factors which may affect the complication rate during and after PCNL. Results: Overall complication rate was 30% in our study population. The most common complications observed were: postoperative fever Grade1-2 (9.52%), and bleeding Grade1 (7.9%), Grade2 (3.17%), Grade3a (4.76%) and Grade3b (1.58%). Nephrostomy tube leakage was not found in our sample, mostly due to specific postoperative utilizing of auxiliary procedures. Conclusion: Reporting of complication for PCNL should be uniform, and modified Dindo-Clavien grading system that is validated for PCNL should be accepted to be a standard in urology. Surgeons training and experience are the most important to ensure the efficacy of procedure, therefore we suggest that learning of percutaneous renal access should be mandatory in residents trainee program.

Key words: percutaneous, nephrolithotomy, PCNL, PNL, urolithiasis, complications, Clavien
stone management after PCNL and should not be considered as complications, this grading system have some limitations that were stressed and analyzed separately.

PREOPERATIVE PREPARATION OF PATIENT

The careful preoperative selection and preparation of patients is the most important factor which influence the complication rate for PCNL. All patient underwent the following diagnostic work-up:

- KUB (kidney-ureters-bladder), Intravenous urography and Ultrasound examination
- Laboratory analyses (complete blood count, biochemistry, urinalysis, urine culture, aPTT and INR)
- Renal scintigraphy (radionuclide imaging with diuretic renal scan)
- Assessment of co-morbidity and previous renal surgery

Absolute contraindication for PCNL were – unregulated coagulopathy, untreated urinary tract infection or pyonephrosis. Antibiotic therapy was given to all patients preoperatively to treat urinary tract infection in those with positive urine culture, and prophylactic in patients with sterile urine culture.

TECHNIQUE OF PCNL

Whole procedure was performed in operating room with patient in general anesthesia. Cystoscopy was performed with retrograde placement of ureteral catheter 6F in kidney that was going to be used subsequently for contrast injection. Foley catheter was placed in bladder. Position of the patient on operating table was prone which is a standard in our institution. Puncture of collecting system was performed exclusively by urologist. Combination of ultrasound and fluoroscopy was used to determine the place for incision on the skin and direction for needle to enter desired calyx. The most common site for puncture was lower pole calyx. Once we have entered collecting system and obtain urine after aspiration, guidewire with soft tip was introduced through the needle and the best position far from lower calyx is established. If pyuric urine was found to be present, procedure was terminated and nephrostomy tube left to drain infected urine. Dilatation and creation of working channel was performed using the serial Alken metal telescopic dilators (Olympus) under fluoroscopy. Then, a standard 26F nephroscope (Olympus) is placed directly into the kidney over the established tract. In majority only one access was performed, and in three cases there were two access in the same procedure. For stone disintegration we have used ultrasonic lithotripter (Olympus) with simultaneous evacuation of debris. If fragments were to big to evacuate in this manner, graspers were used. Throughout the whole procedure, irrigation with isotonic saline solution was used with open system at low pressure. At the end of procedure nephrostomy tube without balloon was placed in the kidney to all patients. Ureteral stent and Foley catheter were remained in situ and were being removed along with nephrostomy tube on second postoperative day when DJ stent was placed in the kidney to all patients. Patient was discharge from hospital on 3-5 day postoperatively with DJ stent in situ, that was being removed usually on 2-3 weeks after procedure.

RESULTS

We have retrospectively analyzed data with regard to complications associated with PCNL in 63 patients treated in a single institution from 2010 to 2013. Overall complication rate was 30% in our study population. The most common complications observed were: postoperative fever Grade1-2 (9.52%) and bleeding Grade1 (7.9%), Grade2 (3.17%), Grade3a (4.76%) and Grade3b (1.58%).

In Table 2 are summarized the relevant studies included in this review and compared with our experience. We have accepted the model how to report complications for PCNL utilizing the modified Dindo-Clavien grading system that is validated for PCNL.

Comparing some points of technique from our experience with those reported in literature, we have discussed important aspects and summarized the most significant factors which may affect the complication rate during and after PCNL.

DISCUSSION

There is a significant heterogeneity in reporting complications associated with PCNL in the contemporary literature. Some authors classifies complications on major and minor, some on intra and postoperative. This considerable variability in complication rates does not allow accurate comparison among different studies. In attempt to standardize the reporting of complications, modified Dindo-Clavien grading system that has been validated for PCNL has been proposed to be used for classification of complications associated with PCNL. European Association of Urology Guidelines Panel in 2012 (10) recommended modified Clavien-Dindo classification for assessment of complications associated with PCNL (Table 1). Recently, the study, conducted by the Clinical Research of the Endourological Society (CROES), utilized the modified Clavien system for reporting complications for PCNL on 5803 patients from 26 countries in 98 centers. The overall complication rate in this study was 21.5%, and the majority of complications were Grade 1-2.

FACTORS ASSOCIATED WITH PREOPERATIVE PREPARATION OF PATIENT

Patient selection – is the the most important factor which may hamper the efficacy of procedure and increase complication rates. Previous operations on kidney does not induce higher complication rates, but affect the duration of surgery and increase the need for auxiliary procedures after PCNL.

Concomitant diseases – major complications (Grade3-4) were 2.7 times higher in patients with Diabete Mellitus and HTA. Recently, it has been reported using Charleston co-morbidity index that comorbidity increase the risk of complications for PCNL. In patients who are grossly obese, or has a spinal deformity, a branched collecting system, or a horseshoe or malrotated kidney, the procedural difficulty is increased. Large stone size will increase rate of complications.
**TABLE**

MODIFIED CLAVIEN-DINDO CLASSIFICATION OF COMPLICATIONS INCLUDING THE NEWLY PROPOSED SUFFIXES "I" AND "F" DEFINITIONS OF OUTCOMES OF SURGERY (Mitropoulos et al. 10)

| Grade 1 | Any deviation from the normal postoperative course without the need for pharmacologic treatment or surgical, endoscopic, and radiologic interventions. Allowed therapeutic regimens are drugs as antiemetics, antipyretics, analgesics, diuretics, electrolytes, and physiotherapy. This grade also includes wound infections opened at the bedside. |
| Grade 2 | Requiring pharmacologic treatment with drugs other than such allowed for grade 1 complications. Blood transfusions and total parenteral nutrition are also included. |
| Grade 3 | Requiring surgical, endoscopic, or radiologic intervention. |
| Grade 4 | Life-threatening complication (including central nervous system complications) requiring intensive care. |
| Grade 5 | Death |

SuffiX "d" If the patient suffers from a complication at the time of discharge, the suffix “d” for disability is added to the respective grade of complication. This label indicates the need for follow-up to fully evaluate the complication.

SuffiX "i" If the patient suffers from a complication at the time of discharge, the suffix “i” for intrasurgical is added to the respective grade of complication. This label indicates a complication that may not cause deviation from the normal postoperative course but is a deviation from the normal surgical procedure.

SuffiX "f" The suffix “f” for follow-up is used if the patient suffers from a complication that is noticed during follow-up beyond 30 postoperative days.

**FACTORS ASSOCIATED WITH INTRAOPERATIVE PREPARATION OF PATIENT AND EQUIPMENT USED FOR PCNL**

**Patient positioning** – careful positioning of patient on operating table is necessary for precise access to kidney. Is it going to be prone or supine position, depends mostly on surgeons experience. Proponents of supine position emphasize advantages such as shorter duration of procedure, simultaneous possibility for retrograde transurethral manipulation, better comfort for surgeon and easy anesthesia, along with the comparable efficacy and complication rates same as with prone position. 15,16,17 But, supine position could be done only with advanced equipment (rotating table and C-arm) and may decrease the mobility of instruments during the procedure, which makes this position not to be a standard in many centers.

**Risk of radiation** – improvements in fluoroscopy equipment during the last years allow us to obtain the good picture with lowest radiation dose. Continuous measurement of radiation exposition during PCNL, as well as periodical controls of equipment are important to decrease the risk of radiation hazards.

**Instruments used for PCNL** – to increase the efficacy and to decrease the complication rate of PCNL, combination of different endoscopic instrument is advisable. Simultaneous use of rigid and flexible nephroscope with different energy used for defragmentation (ultrasonic, ballistic, laser) is the best combination in appropriate manner. For example, to avoid the extreme angulations of rigid instrument when try to reach the upper calyx from the lower pole of the kidney, flexible nephroscope through the same access tract is the best alternative to prevent complications and need for multiple kidney access, especially supracostal. 18 Possibility to use the combinations of instruments are endless, but depends on equipment being available.

**Factors associated with technical aspects of procedure**

**Puncture of collecting system** – in our center, the same as it is in the most of centers in Europe, puncture of kidney is performed by urologist under the guidance of ultrasound and fluoroscopy integradely. This technique allows the most precise identification of surrounding organs and prevent accidental injury. Despite the fact that fluoroscopy is necessary to complete the access to the kidney, utilization of ultrasound guidance significantly decreases the exposing time to radiation during procedure. 37

**Number and localization of access tracts** – the ideal tract is along the axis of calyx through the fornix where the parenchyma is tiniest and no major intrarenal vassals exist. Typically, posterior calyx in lower pole is desired one to enter collecting system of kidney with subcostal approach. Extensive angulations of nephroscope and multiple access points should be avoided. When supracostal approach is used, complication rates (pleural injury) is 5%. 19
TABLE 2
PERCENTAGE OF COMPLICATIONS BY CLAVIEN-DINDO CLASSIFICATION - AN OVERVIEW OF LITERATURE AND OUR EXPERIENCE

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>n</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3a</th>
<th>3b</th>
<th>4a</th>
<th>4b</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>de la Reoxette</td>
<td>2008</td>
<td>244</td>
<td>53.7%</td>
<td>25.8%</td>
<td>16.8%</td>
<td>0.4%</td>
<td>0.4%</td>
<td>0.4%</td>
<td>0</td>
<td>0.3%</td>
</tr>
<tr>
<td>PCNL before 2002</td>
<td>68</td>
<td></td>
<td>39.7%</td>
<td>41.2%</td>
<td>14.7%</td>
<td>1.4%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.4%</td>
</tr>
<tr>
<td>PCNL after 2002</td>
<td>176</td>
<td></td>
<td>59.1%</td>
<td>19.9%</td>
<td>17.6%</td>
<td>0</td>
<td>0.6%</td>
<td>0.6%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>de la Rosette</td>
<td>2011</td>
<td>5724</td>
<td>75.5%</td>
<td>11.1%</td>
<td>5.3%</td>
<td>2.3%</td>
<td>1.3%</td>
<td>0.3%</td>
<td>0.2%</td>
<td>0.03%</td>
</tr>
<tr>
<td>Tzeng et al</td>
<td>2011</td>
<td>101</td>
<td>79.2%</td>
<td>4.5%</td>
<td>4.5%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wang et al</td>
<td>2011</td>
<td>101</td>
<td>83.8%</td>
<td>13.1%</td>
<td>5.1%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>our experience</td>
<td>2014</td>
<td>63</td>
<td>69.8%</td>
<td>12.7%</td>
<td>11.1%</td>
<td>4.7%</td>
<td>1.5%</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

PNCL - percutaneous nephrolitholapaxy

**Placement of the guidewire** – the most important is to avoid perforation of the renal pelvis when introducing the guidewire through the needle into the collecting system after puncturing the calyx. We use a guidewire which has a soft tip that decreases the risk of perforation. In ideal cases the tip of the guidewire should be placed into the ureter, but it is acceptable to coil it in the renal pelvis or calyx distant enough from the place where we entered the kidney.

**Dilatation of tract** – a working channel can be establish using a different instruments for tract dilatation and this is the crucial step in PCNL. Dilatation should always be performed under fluoroscopic guidance. The ideal method of tract dilatation remains a topic of some debate. Which method will be chosen mainly depends on surgeons experience and technical equipment being available. We use serial Alken metal telescopic dilator which is rigid and with main disadvantage that it is difficult to control the pressure and force during dilatation. However, it is a reusable and durable instrument and is less expensive than other methods. More safe is semirigid Amplatz dilator, but balloon dilatation is the most safe, fast and reduces the X-ray exposure of the patients and surgeons and it should be considered as the gold standard among dilators. Only drawback is that balloon dilators are more expensive than other systems.

**Types of Drainage** - after completion of PCNL, the use of nephrostomy tubes for drainage of collecting system is usually recommended and it serves to drain infected urine, to maintain the nephrostomy tract for second-look nephroscopy, to tamponade the bleeding from nephrostomy tract and to prevent the extravasation of urine and formation of urinoma. However, it may be safe and effective not to place nephrostomy tube after PCNL, but only in selected patients. Those who advocate the concept of tubeless PCNL emphasizes advantages such as less pain and shorter hospital stay postoperatively.

Duration of surgery – is important factor that affect the complication rate for PCNL. Based on single-surgeon studies it was estimated that 40-60 cases are necessary to achieve competence in PCNL.

**Parenchymal bleeding** – a common source for a bleeding during PNL is the nephrostomy tract itself. Renal bleeding after PCNL is common and according to published data, transfusion rate was 1-12%, 5.7%, 5-18%. In our study group, 3.17% of patients required transfusion after PCNL. Huge variety in reported data may be explained with different criteria used for transfusion (in our patient group it was Hgb < 80). This complication may be prevented if access to kidney is performed precisely trough the desired calyx, with avoiding multiple puncturing and extensive angulations of nephroscope. If bleeding appear to be significant and impairs endoscopic view, procedure should be terminated and nephrostome tube placed and clamped for 40-60 minutes to tamponade the collecting system and provide haemostasis. Reintervention may be performed after 48h. Sometimes, late onset bleeding complications may occur up to 3 weeks after PCNL, as a result of pus formation or arteriovenous fistula, and usually require treatment with angioselective embolisation. Complication rate reported for this late bleeding is 1%.

**Postoperative fever/bacteraemia** – bacteraemia may occur as a result of infection passing through the access to the kidney or if the stones are infected. Postoperative fever is more frequent in patients with infected stones. Prophylactic use of antibiotics and drainage of obstructed pyonephrosis is mandatory preoperatively. In those patients where sterile urine is found, short-term antibiotic prophylaxis is recommended. Factors that are associated with postoperative fever are duration of surgery and the amount of irrigation fluid used during procedure. To decrease the risk of postoperative fever, it is of most importance to avoid the high pressure in collecting system and not to exceed critical values (102 min and 23 l,
respectively) 6. Sepsis rates reported in literature varies between 0.97% 35 and 4.7% 36. According to the EAU Guidelines, all patients should undergo urinalysis and culture before PNL. In case of a staghorn calculus and/or positive urinalysis, treatment with an appropriate antibiotic should be started at least 1 day before the procedure 37. If preoperative urine culture is sterile, there is a limited evidence that prophylactic use of antibiotic has advantages 35. However, prophylactic use of antibiotics in this setting has not gain consensus yet. In our study group, all patients has received the short-term antibiotic prophylaxis preoperatively. Postoperative fever rates considerably varies in literature reports between 2.8 and 32.1% 37,38, and this can be explained with different antibiotic policy as well as different patient population. Postoperative fever rate in our study group was 9.5%.

**Urine extravasation and absorption of irrigation fluid** – it is common that during the PCNL some amount of irrigation fluid is passing through the perforation on kidney into the perirenal space. To prevent the significant absorption of irrigation fluid, it is recommended to use the open or continuous system with low pressure, to control the manipulation of nephroscope with fluoroscopy and to use always normal saline solution for irrigation 37. Although the absorption is evident in all patients, the complications (i.e. high-fluid volume syndrome) are extremely rare 40. Following the PCNL, urine extravasation is characterized by formation of urinoma or nephrostomy urine leakage. To prevent this complication, it is of most importance to obtain appropriate drainage of collecting system. In most of cases, nephrostomy urine leakage last <12h, but in 1.5-4.6% it may last even longer (>12h.) 41. The most important factor associated with prolonged nephrostomy tube leakage is UP/ureteral obstruction. Nephrostomy tube urine leakage was not found in our sample, mostly due to specific postoperative utilize of auxiliary procedures.

**CONCLUSION**

Although PNL technique has been well established over the past decade, some technical points are still controversial and challenging. Reporting of complication for PCNL should be uniform, and modified Dindo-Clavien grading system that is validated for PCNL should be accepted to be a standard in urology. Surgeons training and experience are the most important to ensure efficacy of procedure, and limit the complication rate. Therefore we suggest that learning of percutaneous renal access should be mandatory in residents trainee program.

**SUMMARY**

Uvod: PCNL je sigurna metoda koja se dobro podnosi, ali kao i svaka hiruška intervencija udružena je sa odredjenim brojem specifičnih komplikacija. U literaturi postoji velika heterogenost u načinu njihovog saopštanja, i na ovaj problem je ukazao Ad Hoc EAU guidelines panel, predlažući neodložno uvođenje uniformnog sistema. Modifikovan Clavien-Dindo sistem za gradiranje dana predstavlja najčešće korišćen sistem za klasifikaciju komplikacija u urologiji, a standard za saopštanje komplikacija posle PCNL. Cilj: Analiza komplikacija u vezi sa PCNL koristeći modifikovan Clavien-Dindo sistem za gradiranje na našem uzorku pacijenata. Metod: U našoj ustanovi, sa povređenim prekidima, PCNL se primenjuje od sredine 2010 godine. Analizirani su podaci u vezi sa komplikacijama PCNL kod 63 pacijenta. Pregledom literature uporedili smo podatke i prihvatili model po kome se podaci u vezi sa komplikacijama treba da prikupljaju i saopštavaju korišćenjem modifikovanog Clavien-Dindo sistema za gradiranje komplikacija kod PCNL. Analizirajući podatke dobijene iz literaturu i poredeci sa našim iskustvima, sumirali smo najznačajnije faktore koji utiču na pojavu komplikacija kod PCNL. Rezultati: Najčešće komplikacije u našem uzorku su bile: postoperativna febrilnost Gradus 1(4.76%), Gradus 2(4.76%) i krvavljenje Gradus 1(7.9%), Gradus 2 (3.17%), Gradus 3a(4.76%) i Gradus 3b(1.58%). Curenje urina posle vadjenja nefrostomskog katetera nije zabeleženo kao komplikacija u našem uzorku, najviše zbog postoperativno specifičnog korišćenja dopunskih procedura. Zaključak: Saopštavanje podataka u vezi sa komplikacijama kod PCNL mora biti uniformno, a klasifikacija modifikovanog Dindo-Clavien sistema za gradiranja komplikacija koja je validirana kod PCNL bi trebalo da postane standard u urologiji. Trening i iskustvo hirurga imaju najveći značaj za uspešno obavljanje ove procedure, stoga smatramo da program specijalizacije iz urologije mora da obuhvati i učenje percutanog pristupa bubrega.

**REFERENCE**


