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Professional Paper

PERCUTANEOUS APPROACH TO THE KIDNEY: SIMILARITIES AND DIFFERENCES OF VARIOUS TECHNIQUES – EXPERIENCE IN OSIJEK UNIVERSITY HOSPITAL CENTER

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SUMMARY – Today, percutaneous nephrolithotomy (PCNL) is a standard procedure in the treatment of large kidney stones. Development of the procedure began in 1976 with publication of the first reports, while turning point came in 1985 when the first 250 cases were described. Subsequently, PCNL has become standard in the treatment of kidney stones instead of open surgery. Numerous modifications of the procedure have been developed with advancement of modern technology. Nevertheless, there is still the necessity for clearer understanding of differences and circumstances of choice among different techniques. There are significant differences in the instruments used for the procedure, so we distinguish standard PCNL (working channel of 24-30 Fr), mini PCNL (working channel of 11-18 Fr), ultra-mini PCNL (working channel <15 Fr), and micro PCNL (working channel <6 Fr). With the development of flexible ureteroscopy (FURS), a combined method is also being developed, i.e., Endoscopic Combined IntraRenal Surgery (ECIRS, PCNL + FURS). Furthermore, each procedure can be performed in prone or supine position. The aim of this paper is to point out the similarities and differences, the advantages and disadvantages of different techniques, with an additional aim to present our experience and current standard practice in kidney stone treatment.

Key words: *Percutaneous nephrolithotomy; Endoscopic Combined IntraRenal Surgery; Supine position; Ureteroscopy; Urolithiasis; Renal calculi*

Introduction

Currently, percutaneous nephrolithotomy (PCNL) is a standard procedure in the treatment of large kidney stones. The introduction of the procedure came in 1976 with publication of the first reports, and in 1985 the first 250 cases were described, which was the turning point[1].

Subsequently, PCNL has become standard in the treatment of large kidney stones. Open surgery is used only sporadically. Advancement of modern technology has led to numerous modifications of the procedure. Nevertheless, there is still a necessity for clearer understanding of different techniques and circumstances of choice among them.

The aim of this paper is to point out the similarities and differences, advantages and disadvantages of different percutaneous techniques, with an additional aim to present our experience and standard practice.

Diagnostic Evaluation

All the procedures are preceded by the same diagnostic evaluation. It includes clinical examination, x-ray scan of the urinary tract,

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ultrasound of the abdomen, and laboratory evaluation including red blood cell count, blood urea nitrogen, creatinine, and urinalysis[2]. Furthermore, contrast-enhanced radiology diagnostic tests must be performed for definitive diagnosis. Today, computed tomography (CT) urography is the gold standard for obtaining detailed appearance of the urinary tract; position, shape and size of the calculus, anatomic relations to other organs, anatomic anomalies, and comorbidities (tumors, aneurysms of abdominal aorta, etc.)[3]. In most cases, placement of JJ stent before surgical procedure in accordance with current indications is performed (e.g., renal colic, increase in inflammatory parameters, etc.) or for prestenting[4]. Before placement of the stent, retrograde pyelography is always performed to get information on the appearance of the urinary tract, and position and size of the stones. Next, non-contrast CT of the urinary tract, which has a high sensitivity for detection of urinary stones[5], is preferred to accelerate the procedure and reduce radiation burden (patients get earlier examination appointment, while for CT urography they must wait for several weeks because of the waiting lists). Furthermore, non-contrast CT is also used in acute evaluation of suspected urinary stones[2]. This way, all data essential for planning and performing the procedure are collected.

In a smaller number of patients, decision is made based on intravenous urography (examination which is still being done in some smaller institutions and usually patients have already done it before coming to our department). Exceptionally, we decide to do surgical procedure only based on retrograde or antegrade pyelography or ultrasound (mostly concerning children in order to reduce radiation).

Indications and contraindications

The indications for PCNL are one of the most important differences that we have noticed in our work as opposed to official guidelines. The European Association of Urology (EAU) guidelines indications for calculi treatment, in general, include calculi growth, obstruction, related infections, and pain. PCNL is the first-line procedure recommended for stones >20 mm and for lower pole stones >10 mm due to the limited effect of extracorporeal shock wave lithotripsy (ESWL) and flexible ureteroscopy (FURS)[2].

By reducing the width of the working channel and by reducing the occurrence of complications, we are progressively widening the indication area. Therefore, we sometimes use mini PCNL for stones less than 10 mm, multiple stones less than 10 mm, and multiple stones at multiple kidney levels.

Some of our potential recommendations are:

- for pediatric population – micro PCNL;
- for stones up to 10 mm – ultra-mini PCNL, mini PCNL;
- for stones 10-20 mm – ultra-mini PCNL, mini PCNL, standard PCNL;
- for stones above 20 mm, staghorn stones – mini PCNL, standard PCNL;
- for multiple stones at several levels – Endoscopic Combined IntraRenal Surgery (ECIRS), ultra-mini PCNL, and mini PCNL with multiple working channels.

Contraindications are identical for all types of procedures. They include uncontrollable urinary tract infection, unregulated coagulopathy, pregnancy, kidney tumor, urothelial tumor, morbid obesity, musculoskeletal and other malformations, and unfavorable position of abdominal organs (intestines, liver)[2].

Does Size Matter?

There are significant differences in the range of instruments. The main difference is in the diameter of the working channel, so we differentiate the following:

- standard PCNL – working channel from 24 to 30 Fr;
- mini PCNL – working channel <18 Fr;
- ultra-mini PCNL – working channel <15 Fr;
- micro PCNL – working channel <6 Fr;
- ECIRS – a combination of PCNL and FURS[6].

There also are differences in the methods of lithotripsy:

- micro and ultra-mini PCNL – laser lithotripsy - due to the small diameter of the instrument, dusting is recommended - ablating the stone into dust like particles which are then washed out through the instrument;
- mini PCNL – laser lithotripsy - dusting is recommended, cracking can be done (controlled destruction of the stones into smaller fragments which are then washed out through the instrument);

- standard PCNL – laser lithotripsy where we recommend cracking or popcorn technique (the stone is destroyed into larger fragments which are then removed with a grasper).

Due to the width of the instrument, it is possible to use ultrasound and other lithotripters[7]. Currently, the only available option in our department is laser lithotripsy.

We use different types of graspers in standard PCNL, while other types of procedures do not require them, and they are not usually used. Stones are washed away with irrigation fluid, which is usually 0.9% NaCl solution.

Other size-related differences in the procedures are seen in the complication rate and length of hospital stay. A smaller working channel causes less damage to the renal parenchyma and surrounding tissues and reduces the percentage of complications during and after the procedure[8].

Prone or Supine?

Each of these procedures can be performed in prone and supine position[9]. Prone position is the position of the patient facing downwards. It was the first position which has been used since 1976[8]. Supine position is the position of the patient facing upwards. Today, there are several modifications (Valdivia, Galdakao, etc.)[10]. Both positions are equally valuable and depend primarily on the preferences of the operator. However, many operators who perform both are increasingly opting for supine position. It is also the case in our institution.

There are a few advantages of prone position, i.e., fixed kidney, more space for manipulation with instruments, and availability of upper kidney pole for puncture.

The advantages of supine position are numerous. There is a larger range of patients who may undergo surgery (patients who are unable to position on their stomach can mostly lie on their back), intubation and supervision by the anesthesiologist are facilitated, physiological position of abdominal organs, less manipulation with the patient, better 'washout' of fragments, lower intrarenal pressure, shorter duration of operations, and perhaps the most important advantage is the possibility of simultaneous FURS (mini ECIRS). Finally, the operator has less radiation exposure and is able to sit while performing the procedure[11].

Our Experience

Percutaneous approach for the treatment of kidney stones has been used in our facility since 1985. Regarding this, until 2018, we had been using only standard PCNL in prone position. Since 2018, we have been performing different techniques of percutaneous approach to kidney stone treatment, for example, mini PCNL in supine position. As of 2020, we have performed mini ECIRS too. Over 100 procedures a year are performed by several surgeons. The number of procedures dating from 2018 to July 2021 is listed in Table 1.

During 2021, until July, we had done 64 percutaneous procedures (41 mini PCNL/23 mini ECIRS). All the procedures were performed in supine position. In 10.9% of patients, these were additional procedures following ESWL. Twenty-six (40.7%) patients had 3 or more stones or staghorn stones. In 23 (35.9%) patients, stones were bigger than 20 mm. Twenty-seven (42%) patients had stones at different levels of the pyelocaliceal system. In most cases (68.7%), the procedure took from 60 to 120 minutes, while only in 3 cases the procedure took more than 180 minutes. All patients had both the ureteral stent and nephrostomy tube after the procedure, along with an antibiotic prophylaxis. We achieved a stone free rate

Table 1. Number of procedures in treatment of urinary stones annually

	2018	2019	2020	2021(until July)
PCNL/ECIRS	33	124	142	64
URS/FURS	177	249	255	96
JJ stent	337	411	470	204
ESWL	337	397	234	98

PCNL/ECIRS = percutaneous nephrolithotomy/Endoscopic Combined IntraRenal Surgery; URS/FURS = ureteroscopy/flexible ureteroscopy; ESWL = extracorporeal shock wave lithotripsy

Table 2. Stone free rate and length of hospital stay in patients treated percutaneously in 2021

	Stone free rate, n (%)
Total	43/64 (67.1%)
Stones <2 cm	36/41 (87.8%)
Stones >2cm	7/23 (30.4%)
	Length of hospital stay, n (%)
≤3 days	46/64 (71.9%)
4-5 days	11/64 (17.2%)
≥6 days	7/64 (10. 9%)

of 67.1% and most of the patients were discharged from the hospital within 3 days of the procedure (71.9%).

Most of the procedures were performed without complications (92.2%). There were 5 cases of complications (inability of achieving percutaneous approach, intraoperative bleeding, postoperative bleeding, urosepsis, and moderate acute urinary infection).

Discussion and Conclusion

In clinical practice, we have noticed some similarities, but also numerous differences among different percutaneous techniques. Now there are so many of them that we can distinguish several different surgical procedures.

The literature on modern minimally invasive percutaneous procedures is still scarce; there is a small body of scientific papers about ECIRS and especially mini ECIRS. These variations of techniques have not yet been used extensively in most centers specialized in urolithiasis.

Our conclusions are mostly based on our experience, in accordance with the available literature and official guidelines, but with some variations. Following this, we have noticed a significant increase in the number of percutaneous procedures in comparison to ESWL at our department. There are many situations in which we perform percutaneous procedures for small stones or stones suitable for ESWL. Mini ECIRS or mini PCNL with multiple working channels are our first options for multiple or staghorn stones. In this way, we often avoid repeated procedures or hospital stays in the same patient.

Since 2020, in most cases, we have performed supine mini PCNL and mini ECIRS and have achieved the same, if not better, results in comparison to standard PCNL. We usually achieve a similar stone free rate in comparison to standard PCNL, with similar operation times and small number of complications. Performing procedures in supine position opens many opportunities, for example, doing ECIRS, which has an important role in the treatment of urinary stones in our department. Supine position has become standard for us and by doing procedures routinely in this position, we always have an option of doing ECIRS, even if it was not planned. Other advantages of supine position are listed above. Standard PCNL is becoming outdated for us, while mini PCNL is becoming more important in case of many indications. This is evident in the number of percutaneous procedures performed during the last 3 years, in comparison to those performed in 2018. The number was mainly higher because of differences in the indications and complication rates.

Given the above, today PCNL is not only standard PCNL, but the term comprises several different surgical procedures which are necessary in specific circumstances and modern urologist needs to have knowledge about the specificities of different PCNL techniques.

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Sažetak

PERKUTANI PRISTUP NA BUBREG: SLIČNOSTI I RAZLIKE U RAZLIČITIM TEHNIKAMA – ISKUSTVO U KLINIČKOM BOLNIČKOM CENTRU OSIJEK

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Perkutana nefrolitotomija (PCNL) danas je standardni postupak za liječenje većih kamenaca u bubregu. Njezin razvoj počinje 1976. godine kada se pojavljuju prvi izvještaji, a prekretnica se dogodila 1985. godie kada je objavljen rad s opisanih 250 slučajeva. Od tada je PCNL kao standard zamijenila otvorenu kirurgiju u liječenju litijaze bubrega. S razvojem tehnologije pojavljuju se brojne modifikacije samog zahvata. Potrebno je još bolje razumijevanje različitih tehnika kao i njihovog odabira u različitim situacijama. Razlike su sada značajne u samom instrumentariju pa tako razlikujemo standardnu PCNL (radni kanal od 24-30 Fr), mini PCNL (radni kanal od 11-18 Fr), ultra-mini PCNL (radni kanal <15 Fr) i micro PCNL (radni kanal <6 Fr). S razvojem fleksibilne ureteroskopije (FURS) razvija se i kombinirani način rada, ECIRS (*Endoscopic Combined IntraRenal Surgery*, kombinacija PCNL + FURS). Nadalje, svaki od zahvata može se raditi u pronacijskom ili supinacijskom položaju. Cilj je ovoga rada ukazati na sličnosti i razlike, prednosti i nedostatke pojedinih tehnika te dodatno prikazati naša iskustva i sadašnje standarde u liječenju bubrežnih kamenaca.

Ključne riječi: *Perkutana nefrolitotomija; ECIRS; Supinacijski položaj; Ureteroskopija; Urolitijaza; Bubrežni kamenci*