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# Comparative Evaluation Of The Efficacy And Frequency Of Intra- And Postoperative Complications In Endoscopic Combined Intrarenal Surgery And Percutaneous Nephrolithotripsy Of Coral Stones

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***Abstract***
*To compare the effectiveness and frequency of intra- and postoperative complications in the treatment of coralloid stones using endoscopic combined intrarenal surgery (EKIH) and percutaneous nephrolithotripsy (PNLT). The study included 131 patients with coralloid nephrolithiasis, 61 of them were treated with the EKIH method, 70 with PNLT. Demographic data, surgery parameters, complication rate, and stone clearance for the 3rd month after the intervention were analyzed. The frequency of achieving stone-free status was significantly higher in the group of the same (85.2% vs. 72.9%, p = 0.048). Intra- and postoperative complications occurred less frequently with ECI (8.2% vs. 20.0%, p = 0.048). The operative time in the group was higher, but it was accompanied by less blood loss and shorter hospital stays. EKIH is a more effective and safe method of treating coral stones, which reduces the risk of complications and improves clinical outcomes compared with NLT.*

***Keywords***: *coral stones, endoscopic combined intrarenal surgery, percutaneous nephrolithotripsy, urolithiasis, stone-free rate, complications, treatment of nephrolithiasis.*

## INTRODUCTION

Coral-shaped kidney stones (staghorn calculi) are concretions that occupy the cup-pelvis system of the kidney and alter its structure for a second time. The frequency of their detection among all cases of urolithiasis is approximately 2-20%, depending on the region, age of patients and concomitant infections. These formations are often associated with chronic urinary tract infections (especially uretero- and cystobacteriosis), decreased renal function, anatomical changes in the kidney, and an increased risk of developing urosepsis. If full-fledged therapy is not carried out, coral stones can cause significant deterioration of kidney function, chronic pain and form foci of chronic inflammation, which can become a source of systemic effect on the entire body [1]. Thus, timely and radical removal of coral stones provides not only urological, but also systemic preventive benefits. This helps to preserve renal function, reduce the risks of infectious and hemorrhagic complications, and improve the quality of life of patients [2].

Since 1976, percutaneous nephrolithotripsy has been the "gold standard" in the treatment of large and coral-like nodules. The method consists of percutaneous access to the renal pelvis under the control of ultrasound or X-ray, expansion of the canal and the introduction of tools for crushing stones (ultrasound, laser or rotary mechanical). The main advantages are the great opportunity to extract fragments of a single session and proven effectiveness. However, massive formations often require multiple procedures, which increases the risk of bleeding, urinary fistula formation, and secondary infections, especially in patients with recurrent conditions [3]. The main complications described in the literature are bleeding (from minimal to requiring intervention), transitional epithelium, pyelonephritis, and acute septic reactions. The level of complications depends on the surgeon's experience, the size and location of the stone, as well as concomitant pathology (obesity, diabetes mellitus, nephropathy) [4].

EKIH combines anterograde (through percutaneous access — nephroscopy) and retrograde (through the urethra — flexible ureterorenoscope) endoscopic approaches in one session. The stone is crushed by a golemium laser (Ho:YAG), fragments are extracted by baskets, sometimes using aspiration. The combined approach makes it possible to shorten procedures, enhance visualization, reduce tissue injury, and reduce the risk of recurrent obstruction [5].

The advantages of these include less blood loss, minimal access, and precise manipulation. But the method requires the coordinated work of several endoscopists and specialized equipment, as well as the time to install both accesses and perform complex anesthesia [6].

Complications accompanying the treatment of coral stones can be divided according to the time of their occurrence — intraoperative and postoperative. Intraoperative complications include bleeding (up to internal bleeding requiring hemostatic intervention), organ damage (for example, fecal or thoracic complications with high access), damage to the collector system, and intraoperative sepsis. The postoperative period is characterized by the risk of abscesses, fistula formation, postoperative sepsis, bacteriuria, renal failure and prolonged pain syndrome [7].

In PNLT, the main cause of complications remains bleeding, especially with multiple procedures, dilation of the renal canal of more than 30 Fr, the presence of anatomical abnormalities and in elderly patients. Traumatic damage to paranephric tissues and retroperitoneal blood accumulations are also observed [8].

In the case of these diseases, despite the reduced tissue injury, there is still a risk of gas embolism, especially when using washing media, as well as the risk of infectious complications. In addition, prolonged placement of the nephrostomy tube can contribute to ascending infections and alcohol syndrome [9].

The aim of the study was to compare the efficacy and frequency of intraoperative and postoperative complications in ECI and PNLT in coralloid kidney stones.

Tasks:

1. Identify the frequency of intraoperative complications (bleeding, organ injury, technical complications) and compare it between groups.
2. Identify postoperative risks (infections, fistulas, kidney failure, hospitalization).
3. Analyze success rates: partial/complete removal of concretions, repeated procedures.
4. Identify risk factors for complications (age, concomitant pathology, stone size, etc.).
5. Evaluate the duration of hospitalization and recovery.

In the light of the lack of uniform comparative data and in the presence of retrospective evidence of the effectiveness of such studies, this study aims to close the existing gap in the literature. This will improve coral calculus management algorithms and reduce the negative effects of treatment. In the future, the work may form the basis of recommendations for practicing urologists, as well as become a starting point for multicenter randomized trials [10].

## MATERIALS AND METHODS

The study was performed as a single-center prospective cohort comparison of two surgical methods for the treatment of coralloid kidney stones. The recruitment of patients was carried out from January 2022 to December 2024 in the Department of Endourology.

Inclusion criteria

- Coral-like stone ≥ 2 cm, confirmed by CT scan with contrast;
- preserved function of the affected kidney (≥ 30% according to dynamic nephroscintigraphy);
- absence of an active purulent-inflammatory process at the time of surgery;
- age 18-75 years; creatinine clearance ≥ 45 ml/min/1.73 m2.

Exclusion criteria

- congenital anomalies of the urinary tract that require reconstruction;
- coagulopathy, incomplete anemia (Hb < 90 g/l);
- pregnancy;
- Two-sided coral-like stones that require a staged approach.

Preoperative examination

- General and biochemical blood tests, ESR, C-reactive protein;
- urine — general examination + seeding;
- CT scan (0.625 mm section) to estimate the volume of the stone (3D reconstruction and calculation using the Ellenstas formula);
- Ultrasound of the kidneys and Dopplerography to exclude vascular abnormalities;
- ECG, chest X-ray.

24 hours before the intervention, all patients were prescribed preventive antibiotic therapy according to local protocols (third-generation cephalosporins or a combination of piperacillin/tazobactam).

Operational equipment

Group 1 —
SIMILAR 1. Retrograde stage: installation of a 12/14 Fr ureteral access-sheath, introduction of a flexible ureterorenoscope (fURS 7.5 Fr; working channel 3.6 Fr).

2. Anterograde stage: under ultrasound/X-ray control — puncture of the calyx-pelvis system, single-stage augmentation up to 24 Fr, introduction of a nephroscope.

3. Stone crushing — Ho:YAG laser (120 W, 0.8–1.2 J × 15-20 Hz) with dusting & fragmentation technique; fragments > 4 mm were extracted with a Dormia basket through nephroscopic access or retrograde.

4. At the end, fURS control, installation of an internal JJ—stent 6 Fr for 10-14 days, nephrostomy 14 Fr if necessary (bleeding, residual fragments).

Group 2 — PNLT

1. Percutaneous Sten-type access in a position on the abdomen; the channel was expanded to 26-30 Fr with a metal telescopic dilator.

2. Crushing — ultrasonic lithotripter + pneumatic or Ho:YAG laser for solid concretions.

3. Removal of fragments using the LithoVac aspiration system.

4. Mandatory installation of nephrostomy 18-20 Fr for 48-72 hours; JJ-stent according to indications (obstruction, mucosal edema).

Both groups underwent surgery under general inhalation anesthesia with controlled hypotension (MAP 60-65 mmHg) to reduce blood loss. The intrathubar irrigation pressure did not exceed 30 cm of water (gravity feed).

Effectiveness assessment

- Stone-free rate — absence of fragments ≥ 4 mm on CT after 3 months.
- Single—session treatment - stone-free without repeated interventions.
- Secondary indicators: duration of surgery (skin-to-skin), intraop. blood loss (Hb difference/hemodilution), infusion volume, duration of hospitalization.

Safety assessment

- Intraoperative complications — according to Clavien–Dindo II+ (bleeding > 300 ml, chest perforation, pleural injury, intraoperative fever > 38 °C).
- Postoperative complications — infectious and inflammatory (OI, sepsis), hematoma/hemorrhage, persistent urine leakage > 48 hours, stent obstruction, refractory pain.
- Hematoma was detected by ultrasound/CT scan, volume > 30 ml — clinically significant.

**RESULTS**

1. Demographic and clinical characteristics.

Analysis of the initial data showed that the groups were comparable in terms of basic demographic and clinical and laboratory parameters ($p > 0.05$), which allows them to be considered statistically homogeneous and comparable in terms of intervention conditions.

| **Indicator** | **ECI Group (n=61)** | **PNLT group (n=70)** | **p-value** |
|---|---|---|---|
| Mean age, years | 52.4 ± 11.3 | 53.7 ± 12.1 | 0.54 |
| Gender (men), % | 65.6 | 63.2 | 0.75 |
| Mean BMI, kg / m2 | 27.1 ± 3.4 | 26.8 ± 3.7 | 0.62 |
| Stones on the right, % | 55.7 | 58.5 | 0.72 |
| Stones on the left, % | 44.3 | 41.5 | 0.72 |
| Concomitant pyelonephritis, % | 16.4 | 18.6 | 0.70 |

Table 1 demographic and clinical characteristics.

2. Operational parameters.

| **Parameter** | **ECI Group (n=61)** | **PNLT group (n=70)** | **p-value** |
|---|---|---|---|
| Mean duration, min | 94.6 ± 15.2 | 82.1 ± 14.7 | < 0.001 |
| Blood loss, ml | 123 ± 40 | 208 ± 60 | < 0.001 |
| Nephrostomy setting, % | 39.3 | 100 | < 0.001 |
| Hospitalization period, days | 3.2 ± 1.1 | 5.4 ± 1.7 | < 0.001 |

Table 2 operational parameters.

As can be seen, operations in the NLT group were shorter on average, but were accompanied by significantly greater blood loss and significantly longer hospitalization.

3. Effectiveness of treatment.

| Indicator | ECI Group (n=61) | PNLT group (n=70) | p-value |
|---|---|---|---|
| of Stone-free rate after 3 months, % | 85.2 | 72.9 | 0.048 |
| Repeated interventions, % | 13.1 | 24.3 | 0.034 |

Table 3 effectiveness of treatment.

The Stone-free result after 3 months was significantly higher in the group of the SAME. Although the differences in repeated interventions have not reached statistical significance, their tendency speaks in favor of the combined technique.

4. Intraoperative complications.

| Complication | ECI Group (n=61) | PNLT group (n=70) | p-value |
|---|---|---|---|
| Bleeding >300 ml, % | 3.3 | 12.9 | 0.029 |
| Damage to adjacent organs, % | 0 | 1.4 | 0.40 |
| Tool fractures, % | 1.6 | 2.9 | 0.56 |

Table 4 intraoperative complications.

The EKIH group showed a statistically significantly lower incidence of intraoperative complications, especially in terms of blood loss > 300 ml.

5. Postoperative complications (according to Clavien–Dindo ≥ II).

| Complication | ECI Group (n=61) | PNLT group (n=70) | p-value |
|---|---|---|---|
| Infectious complications, % | 4.9 | 11.4 | 0.12 |
| Stricture formation, % | 1.6 | 2.9 | 0.56 |
| Repeated hospitalization, % | 3.3 | 8.6 | 0.18 |
| General complications (Clavien–Dindo ≥ II), % | 8.2 | 20.0 | 0.048 |

Table 5 postoperative complications (according to Clavien–Dindo ≥ II).

Postoperative complications were significantly more common in the NLT group. The difference in the cumulative frequency of Clavien–Dindo ≥ II is particularly pronounced.

6. Subanalysis of risk factors for complications

Multifactorial logistic regression analysis has shown that independent risk factors for intra- and postoperative complications are:

| Factor | HR factor (relative risk) | 95% CI | p-value |
|---|---|---|---|
| Use of PNLT | 2,53 | 1,06–6,01 | 0,036 |
| Age > 60 years | 1,35 | 0,68–2,70 | 0,39 |
| Presence of concomitant pyelonephritis | 1,89 | 0,92–3,88 | 0,08 |
| Operation duration > 90 minutes | 1,74 | 0,83–3,66 | 0,14 |

Table 6 subanalysis of risk factors for complication.

A brief summary of the results

- EKIH demonstrated a higher stone-free rate (85.2% vs. 72.9%), lower blood loss, and shorter hospitalization.

- Intra- and postoperative complications were significantly lower in the group of the same type.
- The PNLT method was associated with a 2.5-fold increase in the risk of complications compared with the EIC.
- Repeated interventions were more often required after PNLT, although the difference was not statistically significant.

## DISCUSSION

In this study, a comparative assessment of the effectiveness and complication profile of two modern methods of treating coral stones was carried out: endoscopic combined intrarenal surgery (EKIH) and percutaneous nephrolithotripsy (PNLT). The results obtained demonstrate the advantage of the combined approach in a number of key parameters: the frequency of achieving the stone-free status, the security profile, as well as the level of resource consumption.

One of the most important indicators of the success of surgical intervention in the treatment of coral nephrolithiasis is the achievement of a "stone-free" state — the absence of clinically significant fragments of calculus after surgery. According to our data, the frequency of complete stone removal after 3 months was 85.2% in the EKIH group, while in the PNLT group it was 72.9% ($p = 0.048$). These results are comparable with the data of other authors. For example, in a study by Somani et al. (2020), conducted on a cohort of 210 patients, the SFR with combined access was 84%, while with standard NLT it was about 70%. The difference is due to the fact that the EKIH allows simultaneous use of anterograde and retrograde access, improving visualization of the cavity of the pelvic system, as well as providing more complete removal of fragments.

It should also be noted that there is a tendency towards a lower frequency of repeated interventions in the EH group (13.1% versus 24.3% in the NLT group), which indicates the potential of the combined technique as a more radical method with a lower likelihood of recurrence.

Despite the fact that the average duration of surgery for ECI was higher (94.6 minutes versus 82.1 minutes, $p < 0.001$), this indicator is justified by a more gentle intraoperative course and less blood loss: on average 123 ml versus 208 ml for PNLT ($p < 0.001$). This is due to the smaller diameter of the percutaneous access (24 Fr versus 26-30 Fr) and the use of more gentle methods of stone destruction (laser crushing in the dusting mode with low energy flow). In addition, hypotensive anesthesia and visual monitoring by a flexible ureteroscope allow for better control of hemostasis.

The frequency of nephrostomy placement in the EH group was significantly lower (39.3% versus 100%, $p < 0.001$), which contributed to a reduction in pain, shorter hospital stays, and a reduced risk of postoperative infection. A similar trend was observed with regard to the duration of hospitalization: patients who underwent ECI were discharged after an average of 3.2 days, whereas after PNLT — after 5.4 days ($p < 0.001$).

A comparative analysis of complications showed that the total number of intraoperative and postoperative complications (Clavien–Dindo ≥ II) was statistically significantly lower in the group of the same (8.2% vs. 20.0%, $p = 0.048$). The difference in the frequency of significant intraoperative blood loss (> 300 ml) is particularly pronounced, which indicates the greater traumatism of standard PNLT. It should be borne in mind that massive coral-like stones require multiple accesses and more extensive destruction of the parenchyma with mono-access, which increases the risk of complications.

The level of infectious complications (late fever, pyelonephritis, urosepsis) It was also lower in the group of the same, although statistically significant differences were not achieved in all indicators. This may be due to more accurate control of intrarenal pressure when using a combined approach, especially when aspiration systems are connected and there is no excessive irrigation flow.

Multifactorial analysis confirmed that the use of PNLT increases the risk of complications by more than 2.5 times (HR 2.53; $p = 0.036$), which underlines the clinical importance of choosing surgical tactics in this category of patients.

## CONCLUSION

A comparative study of the efficacy and frequency of intra- and postoperative complications in the treatment of coralloid stones using endoscopic combined intrarenal surgery (EKIH) and percutaneous nephrolithotripsy (PNLT) allowed us to establish the following key provisions:

1. The effectiveness of treatment:

Combined ECI demonstrated a higher frequency of achieving the stone-free state after 3 months (85.2% versus 72.9% with PNLT, p = 0.048), which indicates its greater radicality and clinical effectiveness in the treatment of complex coral nodules.

2. Safety of intervention:

ECI was accompanied by a significantly lower level of intraoperative blood loss and a lower incidence of complications (8.2% vs. 20.0%, p = 0.048), including hemorrhagic and infectious. Combined access also required less frequent installation of nephrostomes and provided a shorter postoperative period.

3. Reducing the burden on the patient:

The use of EIC made it possible to reduce the duration of hospitalization (3.2 days versus 5.4 days for PNLT, p < 0.001) and reduce the need for repeated interventions.

4. Risk factors for complications:

The PNLT method was an independent prognostic factor for increasing the risk of complications (HR = 2.53; p = 0.036), which emphasizes the need for careful selection of the treatment method in patients with large coral stones.

Thus, endoscopic combined intrarenal surgery is a highly effective and safe method of treating coralloid nephrolithiasis, providing a high level of stone clearance with less injury.

The choice of this method is especially justified in patients with an anatomically complex pelvic system, concomitant diseases and a high risk of complications.

The introduction of a combined approach into routine urological practice requires appropriate technical equipment, surgical training and multidisciplinary planning, but at the same time allows achieving optimal clinical results in the treatment of one of the most complex forms of urolithiasis.

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