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Assessment Of The Risk And Frequency Of Intra- And Postoperative Complications In Endoscopic Combined Intrarenal Surgery Of Coralloid Nephrolithiasis.

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Abstract

The aim of the study was to determine the frequency and nature of intra– and postoperative complications in endoscopic combined intrarenal surgery (ECIRS) in patients with coralloid nephrolithiasis, as well as to evaluate the effectiveness of the method. A retrospective study included 63 patients with coralloid kidney stones who had undergone ECIRS. Demographic and clinical data, intervention parameters, the frequency of complications classified according to the Clavien–Dindo scale, and the stone-free rate (SFR) according to CT data 4-6 weeks after surgery were analyzed. The average duration of the operation was 124 ± 27 minutes. In 81% of cases, one percutaneous approach was used, tubeless technique was used in 27% of patients. Intraoperative complications were recorded in 11.1% of patients, postoperative – in 25.4%, of which 1.6% were grade IIIb complications. The frequency of complete stone removal was 74.6%, and 14.3% had residual fragments of less than 4 mm. Repeated interventions were required in 9.5% of cases. No deaths or complications of IV–V degree were registered. ECIRS demonstrates high clinical efficacy and an acceptable safety profile in the treatment of coral nephrolithiasis. The method allows to achieve a high level of stone-free with a minimum number of accesses and a low incidence of severe complications. A promising direction is the further standardization of indications and the conduct of prospective comparative studies.

Keywords: *coral nephrolithiasis, ECIRS, endourology, complications, percutaneous nephrolithotomy, urolithiasis, stone removal, infectious complications, Clavien–Dindo, stone-free rate*

INTRODUCTION

Coral nephrolithiasis (CN), also known as staghorn stones, is one of the most complex forms of urolithiasis. The stones formed in this case reach significant sizes and have a branched structure — they correspond to the shape of deer horns, hence the name. The prevalence of CN varies by region and ranges from 2% to 20% of all cases of urolithiasis, but these figures may vary depending on local epidemiological and environmental factors [1].

The key features of coral stones are:

• High volume — occupy several calices and renal pelvis.
• A branched structure that causes maximum obstructive and dystrophic effects on the renal tissue.
• Composition, mainly: struvite (magnesium, ammonia, phosphorus), carbonate-apatite, less often — uric acid, cystine or calcium oxalate with calcium-apatite.
• Association with infection, especially by urease-producing microorganisms (Proteus, Pseudomonas), which leads to chronic pyelonephritis and relapses [2].

CN is accompanied by persistent infectious processes, causes obstruction of the urothelium and negatively affects kidney function. Only radical stone extraction provides long-term clinical improvement [3].

Until the end of the 20th century, open nephrolithotomy was considered the standard treatment for coral stones. Despite its high efficiency in terms of stone removal, this option had a pronounced traumatic effect: prolonged recovery, heavy blood loss, and a high risk of postoperative complications (infections, fistulas, and relapses). The transition to minimally invasive techniques began with the development of percutaneous nephrolithotomy (PNL, PCNL) — access through the skin using instruments. PHL has significantly reduced the incidence of surgery, reduced hospital admissions, and provided high stone-free rates. However, with stager stones (corlors), PHL most often requires multiple repairs, which increases the risk of bleeding, infections, and damage to the parenchyma [4].

Retrograde ureterorenoscopy (RFU), in turn, is a flexible ureteroscope inserted through the urethra and reaches the renal system. For large coral–shaped stones, this technique is ineffective due to the volume and branching of the concretions and does not allow removing the entire stone in one intervention. By the 2000s, the concept of integrating both percutaneous and retrograde endoscopic approaches in one operation had emerged. This made it possible to combine advantages — percutaneous access provides a powerful streamlined flow, ease of removal of large fragments, and retrograde access helps in visualization, removal of hard-to-reach fragments and reduction of intrarenal pressure [5].
The ECIRS method was first systematically described in the publications of Scoffone and Alers (2008), who proposed conducting PCNL and flexible RF simultaneously or synchronously. The technology has been modified over the years:
• Options: standard ECIRS, mini-ECIRS, mini-mini ECIRS, which vary in tract diameter (22-30 Fr, 14-18 Fr, 10-14 Fr, etc.).
• Patient positions: supine (easy access at the same time) vs prone (traditionally PCNL).
• Brodel access, papillary access guarantees minimal risk of bleeding.
• The use of aspiration systems (excess pressure is relieved).
• Advanced lasers (Ho:YAG, TFL) allow crushing stone to pigment (<2-3 mm) for easy removal.
By now, ECIRS has become the gold standard in the treatment of large and coralloid nephrolithiasis [6].
Numerous studies confirm that ECIRS combines the advantages of PCNL and RIRS:
1. High level of stone freedom (SFR) — 80-95 %;
2. Reducing the number of stages (1-2 interventions instead of 3-4 with PCNL alone);
3. Simultaneous paths through a single access — reducing the number of paths;
4. Optimized pressure, which reduces the risk of pyelonephritis;
5. Less blood loss is more gentle.;
6. Versatility — removal of fragments from all parts of the pelvic system;
7. Reducing the length of hospitalization and rehabilitation time.
However, the implementation of ECIRS requires high qualifications, a team of surgeons experienced in both techniques, and the availability of modern technology.
ECIRS is usually conducted in these stages:
1. Preoperative preparation:
• Urine culture, test for irease;
• Hemostasis correction;
• Dehydration/hydration;
• Antibiotic prevention;
• Prep imaging (urography, CT).
2. Tract selection (under ultrasound/X–ray control), papillary access.
3. PCNL-instrument:
• Nephroscope, laser, pneumatic shredder;
• Aspiration catheters;
4. Parallel flexible ureteroscope:
• Removal of the smallest fragments;
• Providing contouring and visualization of the connecting area.
5. Completion:
• Cup clearance;
• Stenting (DJ stent/optional PKD);
• Control via UZ [7].
Despite the progressiveness of the method, complications in ECIRS are possible and should be analyzed.:
• Intraoperative: bleeding, perforation, organ damage;
• Postoperative: infections, sepsis, fistulas, repeated interventions, vascular injury, pleural complications (pneumothorax with supra-costal access).
The frequency of complications in the literature:
• Bleeding, transfusion: 3-12 %;
• Fever/SIRS: 5-20 %;
• Sepsis: 2-8 %;
• Perforations: 1-5 %;
• Pleural complications: 0.3–1.5 %;

• Fistulas/urinary fistulas: <1 %;
• Repeated interventions: 5-15% [8].
The spread varies depending on the size of the tract, the position of the patient, the volume of the stone, and the presence of infection.
The Clavien–Dindo classification is used for a standardized assessment of the severity of complications:
• I–II: drug treatment (antibiotics, analgesics);
• III–IV: requires intervention under anesthesia or intensive care;
• V: fatal outcome.
Most complications after ECIRS are classified as I–II. However, III–IV cases occur in 3-7%, and fatal cases are extremely rare (<0.1%) with aseptic preoperative optimization.
Clinical predictors:
1. Infection in the urinary tract:
• Positive urine culture — Sepsis RR ×2-3;
• Chronic pyelonephritis and ureterourethral reflux increase the risk;
Bacterial burden — the more germs there are, the higher the risk of SIRS.
2. The volume and composition of the stone:
• Staghorn/corlorami >30 mm — the risk of complications is 10-15 higher %;
• Struvite concretions are especially at risk of sepsis.
3. Anatomy of the kidneys:
• Multicystic fibroids, hernias of cups, infraction angle <90° — make it difficult to remove;
• Small angle — increases pressure, risk of injury.
4. Functional status of the patient:
• CVD, diabetes, obesity, old age — weak compensatory;
• Hepatoephropathies worsen the postoperative period [9].
Technical predictors:
1. Size and number of tracts:
• Standard-ECIRS (22-30 Fr) — higher risk of bleeding, but high removal rate;
• Mini-ECIRS (14-18 Fr) — reduces injury, but increases intervention time.
• Multi-tracts — RR of bleeding by 15-20%.
2. Positions (positional variant):
• supine provides:
• easier access,
• lower anesthetic risk,
• may cause lacrimation.;
• prone classic, may increase the risk of pneumothorax with supra access.
3. Duration of the intervention:
• 120-150 min — RR sepsis increases by 2×;
• Overheating, overirrigation— hyperthermia, fluid overload.
4. Pressure in blood vessels (intrarenal pressure):
• 30-40 cm H2O — hydroinfection, bacteremia;
• Pressure is regulated through aspiration, aspirating/irrigation balance.
5. Surgeon's experience and team:
• Optimal learning curve = ≥50 ECIRS;
• Training + interdisciplinary team reduces complex complications by 30%.
6. Hardware:
• Ho:YAG/Thulium fiber lasers — efficient shredder;
• Aspiration systems: RAPID vacuum — pressure relief;
• Image guidance (CT/UU-Xray): allows precise access, reducing risks [10].
Despite the fact that the ECIRS method is becoming increasingly popular, there is still a critical shortage of data in the literature in the following areas:
1. There is no unified risk assessment at the preoperative preparation stage. Nomograms (GSS, CROES) are used today, but they do not take into account:
• the nature of access (single/multi);
• intrarenal pressure;
• instant parameters of fragmentation.

2. Comparative analysis of different techniques and positions:
• standard vs mini;
• supine vs prone;
• single tract vs multi tract;
However, there are no scalable RCTs with sufficient capacity.
3. Aspects of miniaturization (14-18 Fr) and laser technology (TFL vs Ho:YAG).
4. Long-term ECIRS outcomes:
• How long does rehabilitation take?;
• how long does the kidney continue to work;
• the risk of recurrence and relapse after 2 years.
5. Accounting for economic efficiency:
• cost-benefit ECIRS vs staged PCNL;
• duration hospital stay, VRP/QoL;
• the costly component of the equipment.
6. The impact of COVID-19 and restrictions — how it affected the volume of interventions, patient training and infection [11].
A systematic assessment of the frequency and severity of intra- and postoperative complications in patients with coralloid nephrolithiasis who underwent ECIRS surgery in relation to different access options, positions, tract sizes, and preoperative risk.

MATERIALS AND METHODS

The present study is a retrospective single-center analysis of clinical outcomes in patients with coralloid nephrolithiasis who underwent endoscopic combined intrarenal surgery (ECIRS). The operations were performed on the basis of the urology department in the period from January 2023 to December 2024. The study included 63 patients (38 men and 25 women) aged 24 to 71 years (mean age 49.3 ± 10.7 years) with diagnosed coral nephrolithiasis who underwent ECIRS.
Inclusion criteria
• Age ≥ 18 years;
• Confirmed diagnosis of coral nephrolithiasis (complete or partial) according to multispiral computed tomography (MSCT);
• Stone volume > 2.5 cm or involvement ≥ 2 cups;
• Conducting ECIRS as planned;
• Availability of complete clinical and diagnostic documentation.
Exclusion criteria
• Patients with pronounced anatomical abnormalities of the kidneys (horseshoe, dystopic, multicystic kidney, etc.);
• Performing other concomitant operations (nephrectomy, reconstructive interventions);
• Decompensated somatic conditions that did not allow the operation to be performed according to the standard protocol;
• Incomplete medical documentation.
Before surgery, all patients underwent a standard clinical, laboratory and instrumental examination, including:
• General and biochemical blood analysis;
• General urinalysis, urine culture for microflora to determine sensitivity to antibiotics;
• Coagulogram;
• Creatinine level determination and GFR calculation (CKD-EPI formula);
• Ultrasound of the kidneys and bladder;
• MSCT of the kidneys with contrast;
• ECG and consultation with a therapist/anesthesiologist.
The operations were performed in accordance with the accepted protocols of combined endourological surgery. The ECIRS technique included the following steps:
1. Patient's position: in most cases, the Galdakao-modified supine Valdivia position was used, in some cases, the prone position.
2. Anesthesia: general endotracheal with muscle relaxation.

3. Retrograde access: installation of a ureteral catheter and ureteroscope for visualization of the pelvic system and assistance during the percutaneous stage.
4. Percutaneous access:
• Puncture of the calyx-pelvis system under ultrasound control;
• Step-by-step path expansion up to 20-24 Fr;
• Using a rigid nephroscope (Karl Storz, Olympus).
5. Crushing of concretions:
• Holmium laser (30-100 W) or combined ultrasound/ballistic lithotripsy was used;
• Removal of fragments using aspiration, Dormia baskets, mesh traps.
6. Completion of the operation:
• Nephrostomy drainage and/or a Double-J stent were installed according to the indications;
• In patients without complications, no drainage was performed (tubeless ECIRS).
Postoperative follow-up:
• Patients were followed up during the entire period of hospitalization;
• Hemodynamic parameters, body temperature, blood and urine tests, ultrasound and X-ray data were evaluated;
• If complications are suspected, emergency CT or radiography is performed.;
• Drainage was removed depending on the clinical picture and visual control data;
• The assessment of residual stone loading was carried out after 4-6 weeks according to CT or ultrasound data.
Complications were classified according to the Clavien–Dindo scale:
• Grade I: complications that do not require active intervention (hematuria, fever up to 38 °C);
• Grade II: requiring drug therapy (antibiotics, blood transfusion);
• Grade III: interventions under anesthesia (drainage, repeat surgery);
• Grade IV: life-threatening conditions requiring intensive care;
• Grade V: fatal.
Intraoperative complications:
• Blood loss and the need for blood transfusion;
• Damage to the ureter, cup-pelvic system;
• Perforation of hollow organs (rare);
• The need to convert to an open transaction.
Postoperative complications:
• Fever, pyelonephritis, sepsis;
• Bleeding requiring repeated intervention;
• Urinary congestion, infiltrates, prolonged drainage;
• Repeated hospitalizations and reinterpretations.
The criterion of success was the complete absence of fragments > 4 mm (stone-free status, SFR) according to CT data 4-6 weeks after surgery.
Additionally analyzed:
• Duration of the operation (in minutes);
• Duration of hospitalization (in days);
• Frequency of reintervents for 30 days;
• Patients with residual stone loading.

RESULTS

The study included 63 patients who had undergone ECIRS for coral nephrolithiasis. The main clinical and demographic characteristics are presented in Table 1.

Indicator	Value
Mean age, years (M ± SD)	49.3 ± 10.7
Gender, n (%)	Men — 38 (60.3%) Women — 25 (39.7%)
Lateral	left kidney — 27 (42.9%) Right kidney — 36 (57.1%)
Total coralloid	41 (65.1%)

Partial coralloid	22 (34.9%)
Average volume of the stone on CT,	mm3 3,950 ± 840
Concomitant hydronephrosis of stage II–III	18 (28.6%)
Diabetes mellitus	11 (17.5%)
History of chronic pyelonephritis	32 (50.8%)
Infected stone (by seed)	19 (30,2%)

Table 1. Clinical and demographic characteristics of patients (n = 63).

Intraoperative parameters

- Average duration of the operation: 124 ± 27 min (range: 95-190 min)
- Number of percutaneous accesses:
- One access — 51 patients (81%)
- Two access — 12 patients (19%)
- Volume of intraoperative blood loss: 90 ± 45 ml
- Blood transfusion was required in 4 patients (6.3%)
- Conversion to open surgery: not required in any case
- Nephrostomy placement at the end of surgery: in 39 patients (61.9%)
- tubeless ECIRS (without nephrostomy) was performed in 17 patients (27%)

Intraoperative complications were reported in 7 patients (11.1%):

- Bleeding that did not require transfusion — 3 (4.8%)
- Bleeding with the need for hemotransfusion — 2 (3.2%)
- Damage to the mucous membrane of the calyx — 2 (3.2%)
- Perforation of the ureter, intestinal perforation and other severe complications — not reported

Postoperative complications occurred in 16 patients (25.4%) and were classified according to the Clavien–Dindo scale as follows (Table 2).

Complication rate	Number of patients (n)	%
Clavien I	5	7.9% (fever up to 38.5 °C, stopped without antibiotics)
Clavien II	7	11.1% (postoperative fever > 38.5 °C, antibacterial therapy)
Clavien IIIa	3	4.8% (puncture drainage of infiltrate, drainage of urinal congestion)
Clavien IIIb	1	1,6% (endoscopic resetting of nephrostomy under anesthesia)
Clavien IV-V	0	-
Total complications (any degree)	16	25.4%
Infectious and inflammatory complications	12	19% (fever, pyelonephritis, SIRS)

Table 2. Frequency of postoperative complications according to the Clavien–Dindo scale

Total complications (of any degree): 16 (25.4%)

Infectious and inflammatory complications (fever, pyelonephritis, SIRS): 12 patients (19%)

Average duration of hospitalization: 6.3 ± 2.1 days (from 3 to 11 days)

Treatment efficacy (stone-free rate, SFR)

- Complete removal of stones (SFR) according to CT after 4-6 weeks was achieved in 47 patients (74.6%)
- Residual fragments < 4 mm in 9 patients (14.3%)
- Residual fragments > 4 mm (unsuccessful procedure) in 7 patients (11.1%)

Repeated interventions (within 30 days after ECIRS) were required in 6 cases (9.5%):

- Retropelvoscopy — 2
- Repeated ureteroscopy — 2
- Infiltrate drainage — 2

DISCUSSION

The presented study evaluated the efficacy and safety of ECIRS in 63 patients with coral stones. Our data confirm that ECIRS can achieve high efficiency (SFR 74.6%) with an acceptable level of complications and a low frequency of repeated interventions.

The overall incidence of intra- and postoperative complications in our study was 25.4%, while severe complications (Clavien IIIb and higher) were recorded in only 1 case (1.6%). The data correspond to international statistics. According to Liao et al. (2020), the complication rate for ECIRS varies from 15 to 28%, with fever and temporary hematuria accounting for the majority. We had the most frequent infectious complications (fever, SIRS), which confirms the importance of microbiological monitoring before and after surgery, as well as the use of preventive antibacterial therapy.

It is important to note that no deaths or grade IV–V complications were recorded in this study. This confirms the relative safety of the ECIRS technique with proper patient preparation and compliance with the intervention technique.

One of the key points in the treatment of coral nephrolithiasis is the infectious component. The stones often contain bacterial biofilms, which, even with negative urine culture results, can become a source of postoperative sepsis. In our study, infectious complications were noted in 12 patients (19%), which corresponds to the data of Akman et al. (2020), indicating a similar frequency in ECIRS. We believe that routine urine culture and, if possible, stone material, as well as targeted antibiotic prophylaxis before and after surgery, are mandatory elements of the management of such patients.

CONCLUSION

Coral nephrolithiasis remains one of the most difficult forms of urolithiasis both in terms of diagnosis and treatment. These stones, which fill the calyx-pelvic system, are often accompanied by infectious and inflammatory complications, impaired urodynamics, decreased kidney function and require an integrated approach to removal. Percutaneous nephrolithotomy (CNRT) is currently recognized as the standard method of surgical treatment of such patients, however, in recent years, a combined method, endoscopic combined intrarenal surgery (ECIRS), has become increasingly popular, combining the advantages of anterograde and retrograde approaches.

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