

S. Resetniak 

Kharkiv National Medical University, Kharkiv, Ukraine

# Retroperitoneoscopic resection with preoperative selective embolization and indocyanine green fluorescence visualization of vessels in kidney cancer

For citation: Počki. 2023;12(1):46-49. doi: 10.22141/2307-1257.12.1.2023.394

**Abstract. Background.** Currently, kidney cancer is considered one of the most common oncological pathologies, accounting for 2–3 % of all cancers. In 2018, the total number of primary renal cell carcinoma patients in Ukraine was 4,805 cases, with 1,878 patients dying from this disease. Surgical treatment is the only way for 68 % of patients with localized kidney cancer. The main question remains unanswered — an effective surgical treatment of patients with localized renal cell carcinoma. Our aim was to study the kidney function parameters in localized kidney cancer after retroperitoneoscopic resection with preoperative selective embolization compared to standard kidney resection using thermal ischemia. **Materials and methods.** Data of 65 patients with localized kidney cancer who underwent nephron-sparing surgery were analyzed. They were divided into two groups. The first one included 40 people with localized kidney cancer who underwent standard organ-sparing surgery with duration of thermal ischemia of less than 20 minutes. The second group consisted of 25 patients with localized kidney cancer who underwent computed tomography with renal vessels reconstruction in the preoperative stage. Branch of the renal artery that feeds the area of the kidney with the tumor was identified. As a next step, selective embolization was performed. Retroperitoneoscopic resection was carried out the next day with fluorescence imaging in the infrared light using indocyanine green. **Results.** Analysis of the data shows that renal function after surgery for local cancer in case of retroperitoneoscopic resection with preoperative selective embolization of renal vessels is more functionally suitable compared to kidney resection using thermal ischemia. **Conclusions.** Our data suggest that superselective X-ray vascular embolization and intraoperative indocyanine green fluorescence in the surgical treatment of localized kidney cancer has significant advantages over the standard method of surgical treatment.

**Keywords:** localized kidney cancer; retroperitoneoscopic kidney resection; indocyanine green; superselective embolization; functional postoperative results; nephron-sparing surgery

## Introduction

Renal cell carcinoma over the past two decades has had an annual the incidence in incidence both in Europe and worldwide, which is 2–3 % among all malignancies. The incidence among men is 1.5 times higher than among women. The peak incidence occurs at the age of 60–70 years [1, 2].

Number of patients undergoing surgery for kidney tumors is increasing every year. If in the 1980s their number was 0.21 per 100 thousand, then in 2002 — 1.6, and in 2012 — 2.1 per 100 thousand population. In 2018, the total number of primary renal cell carcinoma patients in Ukraine

was 4,805, with 1,878 patients dying from this disease [3, 4].

Preservation of renal function is one of the main tasks in the treatment of kidney tumors. In addition, most of these patients, who are planned for surgical treatment, are the elderly, many of them already at the stage of cancer diagnosis have preclinical stages of chronic kidney disease (CKD) due to existing comorbidities (diabetes, systemic atherosclerosis, hypertension, chronic urinary tract infections, etc.).

According to the definition of the National Kidney Foundation, CKD is characterized by a decrease in glome-

© 2023. The Authors. This is an open access article under the terms of the Creative Commons Attribution 4.0 International License, CC BY, which allows others to freely distribute the published article, with the obligatory reference to the authors of original works and original publication in this journal.

Для кореспонденції: Решетняк Сергій, лікар Навчального та дослідницького медичного комплексу «Університетська клініка» Харківського національного медичного університету, вул. Шпегера, 4, м. Харків, 61157, Україна; e-mail: rewetnyak2011@gmail.com

For correspondence: Sergii Resetniak, Doctor of the Training and Research Medical Complex "The University Clinic" of the Kharkiv National Medical University, O. Shpeyera st., 4, Kharkiv, 61157, Ukraine; e-mail: rewetnyak2011@gmail.com

Full list of author information is available at the end of the article.

ular filtration rate (GFR) of less than 60 ml/min/1.73 m<sup>2</sup> for 90 days or more with the presence or absence of signs of kidney damage, long-term albuminuria with or without a decrease in GFR [5]. Based on the analysis of many recent studies, it becomes clear that chronic kidney disease is epidemiologically much more common than previously thought [6, 7]. Today, GFR assessment to determine CKD has demonstrated a much higher prevalence of this pathology among the elderly.

According to the medical program “Medicare”, the incidence of CKD in the United States of America in 2006 was 6.4 % (CKD was mainly diagnosed based on serum creatinine level only). This index was significantly lower than the actual incidence of 44.2 %, obtained in the NHANES study, which studied GFR in the population from 1999 to 2006 [8].

Significant prevalence of chronic kidney disease in the population of other countries has been demonstrated by several large studies [5, 9–11]. CKD is usually asymptomatic before the development of late stages. In most cases, CKD is detected before the onset of renal failure symptoms, when effective prevention of the adverse effects on the health and life of a patient often becomes extremely difficult [12].

Quite often, it is difficult to reliably assess the function of the kidney in the presence of a satisfactorily functioning contralateral one. The study of R.H. Thompson, I. Frank, C.M. Lohse et al. (2007) included 537 patients with a single kidney who underwent nephron-sparing surgery for tumor lesions. Patients were divided into three groups: the first one — resection of the kidney without ischemia; the second one — resection of the kidney with thermal ischemia; patients from the third group underwent resection of the kidney with cold ischemia.

Warm and cold ischemia have been associated with a significant risk of developing acute and chronic renal failure compared to patients who did not undergo ischemia [13]. Detection of patients with CKD and prevention of disease progression becomes extremely important in the treatment of renal tumors. At the same time, awareness of the increasing prevalence of CKD and its severe consequences heralded the beginning of a new era of treatment focused on the maximum possible preservation of renal function in patients undergoing resection for malignant neoplasms.

**The purpose** was to study the kidney function parameters in patients with localized kidney cancer after retroperitoneoscopic resection with preoperative selective embolization compared with standard kidney resection using thermal ischemia.

## Materials and methods

Data of 65 patients with localized kidney cancer who underwent nephron-sparing surgery were analyzed. They were divided into two groups. The first one — 40 people with localized kidney cancer who underwent standard organ-sparing surgery with thermal ischemia duration of less than 20 minutes. The second group — 25 patients with localized kidney cancer who underwent computed tomography (CT) with renal vessels reconstruction in the preoperative stage. Branch of the renal artery that feeds the area of the kidney

affected with the tumor was identified. As a next step, selective embolization was performed. Retroperitoneoscopic resection was performed the next day with fluorescence imaging in infrared light using indocyanine green (ICG).

Age of patients ranged from 21 to 82 (median of 67.0) years, mean age was  $58.3 \pm 8.1$  years, the incidence was peak in the age category of 50–69 years — 40 patients (61.53 %). Primary tumor evaluation was based on clinical examination, ultrasound and CT. Stage of the disease was detected after surgery.

Analysis of the disease stages in our studies showed that 23 (35.38 %) patients with local kidney cancer had primary stage I (T1aN0M0), 9 (13.85 %) — T1bN0M0, 33 (50.77 %) — stage II (T2aN0M0).

In all cases, the diagnosis was confirmed morphologically. Functional state of the kidneys was studied in all patients before surgery and after treatment (1, 6 and 12 months after surgery). Tests included serum creatinine and urea, measurement of glomerular filtration rate, urinary albumin excretion, renal ultrasound, CT of the retroperitoneal organs with intravenous contrast or magnetic resonance imaging of the kidneys.

Data analysis was performed using statistical software (Statistica 10). To calculate probability, we used Fisher's exact test, Student's t-test, non-parametric tests, including Mann-Whitney, and Kruskal-Wallis. The significance level  $p < 0.05$  was chosen at the beginning of the experiment. Metrological evaluation performed to all measuring instruments.

## Results

As mentioned above, all patients with localized renal cell carcinoma of the kidney underwent resection. Mean operative time was 88 (68–123) minutes. Intraoperative blood loss averaged 150 (50–750) milliliters. Complications were analyzed using Clavien-Dindo scale. No complications were reported during surgery. During postoperative period, 4 (6.15 %) complications grade I–II were registered. Complications did not affect postoperative renal function. At the preoperative stage, the following methods were used to study renal function (Table 1).

The data obtained from instrumental studies 1 month after surgery in both groups showed the presence of approximately 45 % of subclinical signs of postoperative inflammatory processes in the operated kidney. Also, in the first group with radioisotope renography and CT with intravenous contrast, 16 (35.5 %) patients had a violation of perfusion of the operated organ. In our opinion, this is due to hemostatic sutures involving an unreasonably large number of healthy functionally active parenchyma.

Laboratory data showed a clinically significant decrease in renal function in a group of patients who underwent thermal intraoperative ischemia during kidney resection (Table 2).

It can be assumed that the influence on the development of renal dysfunction in the group of patients who underwent thermal ischemia during kidney resection was due to the greater volume of the removed parenchyma of the operated kidney. According to our data, in 23 of 45 (51.1 %)

patients, the average absolute volume of the operated kidney decreased from 284 to 240 cm. Approximately 2/3 of it was the tumor, and 1/3 was the functionally active renal parenchyma. In the group where preoperative selective embolization with fluorescence imaging was used, a more tissue sparing removal of a healthy renal parenchyma was morphologically proven. In 18 of 20 (90 %) patients, the average absolute volume of the operated kidney decreased from 293 to 270 cm, 18 % were occupied by a functionally active renal parenchyma.

According to instrumental methods of research, urinary disorders were not revealed in both groups 6 and 12 months after surgery (Table 3).

Discussion

Our data suggest that use of superselective X-ray vascular embolization and intraoperative ICG fluorescence imaging in the surgical treatment of localized kidney cancer has significant advantages over the standard method of surgical treatment.

As Pietro Diana et al. showed in a multicenter study (2020), ICG is a reliable tool for guiding the surgeon strategy during partial nephrectomy. ICG may help in procedure tailoring, especially in cases with challenging vascularization or impaired renal function.

We see the prospects for further study and implementation of the proposed algorithm for examination and treatment of patients with this pathology.

Conclusions

Analysis of the data shows that renal function after surgery for local cancer in case of retroperitoneoscopic resection with preoperative selective embolization of renal vessels is more functionally suitable compared to kidney resection using thermal ischemia.

Most clinically significant changes of renal function were observed in the first group one month after the surgery (kidney resection with thermal ischemia). Patients had an increase in serum creatinine, urea by an average of 20 %, deteriorating GFR, more frequent albuminuria, which in some cases required additional medical correction.

In the second group, we did not register any clinically significant renal dysfunction at all. At the same time, it should be noted that after 6 and 12 months of follow-up, in both groups renal function was approximately similar.

Our data confirms that the proposed method of retroperitoneoscopic resection with preoperative vascular embolization and intraoperative ICG fluorescence imaging is preferable in patients with localized kidney cancer.

Table 1. The results of studying renal function in patients with local kidney cancer before surgery

Indicators	Group I (n = 40)	Group II (n = 25)
Serum creatinine, μmol/L	74.5 (65–144)	78.5 (58–121)
Serum urea, mmol/L	6.45 (4.2–8.7)	7.05 (5.1–9.0)
GFR (Cockcroft-Gault formula), ml/min/1.73 m <sup>2</sup>	88.5 (65–118)	86.5 (59–110)
Urinary albumin excretion	2 (4.4 %)	1 (4 %)

Notes: here and in Tables 2, 3: data were expressed as median (95% confidence interval); differences between groups are reliable, p < 0.05.

Table 2. The results of studying renal function in patients with local kidney cancer one month after surgery

Indicators	Group I (n = 40)	Group II (n = 25)
Serum creatinine, μmol/L	98.9 (87–164)	81.3 (81–118)
Serum urea, mmol/L	7.9 (5.2–9.6)	7.4 (5.4–9.7)
GFR (Cockcroft-Gault formula), ml/min/1.73 m <sup>2</sup>	64.1 (49–90)	84.9 (54–112)
Urinary albumin excretion	13 (28.8 %)	4 (16 %)

Table 3. The results of studying renal function in patients with local kidney cancer 6 and 12 months after surgery

Indicators	Group I (n = 40)		Group II (n = 25)	
	6 months after surgery	12 months after surgery	6 months after surgery	12 months after surgery
Serum creatinine, μmol/L	86.8 (64–155)	89.9 (68–137)	81.3 (60–118)	80.9 (56–119)
Serum urea, mmol/L	7.1 (5.2–7.6)	7.7 (5.3–8.3)	6.4 (5.0–6.9)	7.04 (5.4–7.9)
GFR (Cockcroft-Gault formula), ml/min/1.73 m <sup>2</sup>	74.2 (56–101)	74.8 (51–104)	84.9 (58–112)	85.9 (62–109)
Urinary albumin excretion	3 (6.66 %)	1 (2.22 %)	1 (4 %)	0

## References

1. Scelo G, Larose TL. Epidemiology and Risk Factors for Kidney Cancer. *J Clin Oncol*. 2018 Oct 29;36(36):JCO2018791905. doi: 10.1200/JCO.2018.79.1905.
2. Scelo G, Hofmann JN, Banks RE, et al. International cancer seminars: a focus on kidney cancer. *Ann Oncol*. 2016 Aug;27(8):1382-5. doi: 10.1093/annonc/mdw186.
3. Fedorenko ZG, Gulak LO, Mihailovich UI, et al, authors. Kolesnik OO, editor. Cancer in Ukraine, 2017–2018. Incidence, mortality, activities of the oncological service. *Bulletin of the National Cancer Registry of Ukraine, Vol 20*. Kyiv: National Cancer Institute; 2019. 84 p. Available from: [http://www.ncru.inf.ua/publications/BULL\\_20/index\\_e.htm](http://www.ncru.inf.ua/publications/BULL_20/index_e.htm). Accessed: 2023 Mar 21.
4. Fedorenko ZG, Mihailovich UI, Gulak LO, et al, authors. Kolesnik OO, editor. Cancer in Ukraine, 2014–2015. Incidence, mortality, activities of the oncological service. *Bulletin of the National Cancer Registry of Ukraine*. Kyiv: National Cancer Institute; 2017. 16. Available from: [http://www.ncru.inf.ua/publications/BULL\\_17/index\\_e.htm](http://www.ncru.inf.ua/publications/BULL_17/index_e.htm). Accessed: 2023 Mar 21.
5. National Kidney Foundation. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Am J Kidney Dis*. 2002 Feb;39(2 Suppl 1):S1-266.
6. Krstic D, Tomic N, Radosavljevic B, et al. Biochemical Markers of Renal Function. *Curr Med Chem*. 2016;23(19):2018-40. doi: 10.2174/0929867323666160115130241.
7. Bowling CB, Muntner P. Epidemiology of chronic kidney disease among older adults: a focus on the oldest old. *J Gerontol A Biol Sci Med Sci*. 2012 Dec;67(12):1379-86. doi: 10.1093/gerona/gls173.
8. Collins AJ, Foley RN, Herzog C, et al. United States Renal Data System 2008 Annual Data Report. *Am J Kidney Dis*. 2009 Jan;53(1 Suppl):S1-374. doi: 10.1053/j.ajkd.2008.10.005.
9. Afkarian M, Zelnick LR, Hall YN, et al. Clinical Manifestations of Kidney Disease Among US Adults With Diabetes, 1988–2014. *JAMA*. 2016 Aug 9;316(6):602-10. doi: 10.1001/jama.2016.10924.
10. Saydah SH, Xie H, Imperatore G, Burrows NR, Pavkov ME. Trends in Albuminuria and GFR Among Adolescents in the United States, 1988–2014. *Am J Kidney Dis*. 2018 Nov;72(5):644-652. doi: 10.1053/j.ajkd.2018.04.021.
11. Grams ME, Sang Y, Ballew SH, et al; CKD Prognosis Consortium. A Meta-analysis of the Association of Estimated GFR, Albuminuria, Age, Race, and Sex With Acute Kidney Injury. *Am J Kidney Dis*. 2015 Oct;66(4):591-601. doi: 10.1053/j.ajkd.2015.02.337.
12. Smart NA, Dieberg G, Ladhani M, Titus T. Early referral to specialist nephrology services for preventing the progression to end-stage kidney disease. *Cochrane Database Syst Rev*. 2014 Jun 18;(6):CD007333. doi: 10.1002/14651858.CD007333.pub2.
13. Thompson RH, Frank I, Lohse CM, et al. The impact of ischemia time during open nephron sparing surgery on solitary kidneys: a multi-institutional study. *J Urol*. 2007 Feb;177(2):471-6. doi: 10.1016/j.juro.2006.09.036.

Received 18.02.2023

Revised 01.03.2023

Accepted 10.03.2023 ■

## Information about authors

Sergii Resetniak, Doctor of the Training and Research Medical Complex "The University Clinic" of the Kharkiv National Medical University, Kharkiv, Ukraine; e-mail: rewetnyak2011@gmail.com; <https://orcid.org/0000-0001-6760-4309>

**Conflicts of interests.** Author declares the absence of any conflicts of interests and own financial interest that might be construed to influence the results or interpretation of the manuscript.

Решетняк С.

Харківський національний медичний університет, м. Харків, Україна

### Ретроперитонеоскопічна резекція з передопераційною селективною емболізацією та флуоресцентною візуалізацією судин з індоціаніном зеленим при раку нирки

**Резюме. Актуальність.** Сьогодні рак нирки вважається однією з найпоширеніших онкологічних патологій (2–3 % усіх онкологічних захворювань). У 2018 році загальна кількість хворих на первинну нирковоклітинну карциному в Україні становила 4805 випадків, 1878 пацієнтів померли від цієї хвороби. Хірургічне лікування є єдиним шляхом у 68 % випадків локалізованого раку нирки. Залишається без відповіді головне питання — ефективне хірургічне лікування хворих із локалізованою нирковоклітинною карциномою. **Мета:** вивчити параметри функції нирок у пацієнтів із локалізованим раком нирки після ретроперитонеоскопічної резекції з передопераційною селективною емболізацією порівняно зі стандартною резекцією нирки з використанням термічної ішемії. **Матеріали та методи.** Проаналізовано дані 65 хворих на локалізований рак нирки, яким виконано нефронзберігаючу операцію. Їх розділили на дві групи. До першої увійшли 40 осіб з локалізованим раком нирки, які перенесли стандартну органозберігаючу операцію з тривалістю термічної ішемії менше 20 хвилин. Другу групу становили 25 хворих на локалізований рак нирки, яким на доопераційному етапі виконано комп'ютерну томо-

графію з реконструкцією ниркових судин. Ідентифіковано гілку ниркової артерії, що живить ділянку нирки з пухлиною. Наступним кроком була селективна емболізація. Наступного дня проводили ретроперитонеоскопічну резекцію з флуоресцентною візуалізацією в інфрачервоному світлі з використанням індоціаніну зеленого. **Результати.** Аналіз отриманих даних показує, що функція нирки після оперативного втручання з приводу локального раку при ретроперитонеоскопічній резекції з передопераційною селективною емболізацією ниркових судин є більш спроможною порівняно з резекцією нирки з використанням термічної ішемії. **Висновки.** Отримані нами дані свідчать про те, що суперселективна рентгенівська емболізація судин та інтраопераційна флуоресцентна візуалізація з індоціаніном зеленим при хірургічному лікуванні локалізованого раку нирки має значні переваги перед стандартним методом хірургічного лікування.

**Ключові слова:** локалізований рак нирки; ретроперитонеоскопічна резекція нирки; індоціанін зелений; суперселективна емболізація; функціональні післяопераційні результати; нефронзберігаючі операції