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ROBOT-ASSISTED PARTIAL NEPHRECTOMIES – FUNCTIONAL AND ONCOLOGICAL RESULTS

ABSTRACT

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I. INTRODUCTION

Renal cell carcinoma (kidney cancer) is *"the most common tumor of the kidney and accounts for 85-90% of all malignant kidney tumors"* (Vassilev, 2011). It is more common in men than women, with the average age of diagnosis being 64.

Worldwide, the incidence of renal cell carcinoma varies, with over 400,000 new cases and over 170,000 deaths reported annually (Siegal, 2022). In 85% of diagnosed cases in adults and children, renal cell carcinoma has a relatively poor prognostic outlook without a major breakthrough in primary treatment (Choi et al., 2013). Renal cell carcinoma is a heterogeneous group of cancers arising from renal tubular epithelial cells that comprises 85% of all primary renal neoplasms. The most common subtypes of renal cell carcinoma are clear cell RCC (ccRCC), papillary RCC and chromophobic RCC. The remaining 15% of kidney tumors were transitional cell carcinoma (8%), nephroblastoma or Wilms tumor (5–6%), collecting duct tumors (<1%), renal sarcomas (<1%), and renal medullary carcinomas (<1%) (Nabi, 2018).

In most cases, renal cell carcinoma is slow in development, initially within the kidney, and it is possible to reach large sizes within 15-20 cm. Specific to renal cell carcinoma is "early metastasis by the blood (venous) route, initially to the renal vein, and at a more advanced stage it is possible that the "tumor thrombus" may reach the right cardiac atrium. For this reason, the most common distant metastases are in the lung" (Vassilev, 2011). The stages of renal cell carcinoma are classified on the basis of its spread in the kidney, in neighboring organs and tissues, as well as according to the presence and spread of metastases:

T – Primary tumor

Tx – The primary tumor cannot be evaluated.

T0 – No evidence of primary tumor

T1 – Tumor smaller than 7 cm in its largest diameter, confined to the kidney

T1a – tumor smaller than 4 cm

T1b – tumour larger than 4 cm but less than 7 cm

T2 – Tumor larger than 7 cm in its largest diameter, but limited in the kidney

T2a – tumour larger than 7 cm but less than 10 cm

T2b – tumor larger than 10 cm, confined in the kidney

T3 – A tumor that spreads to the large veins or perinephral fat tissue, but not to the ipsilateral adrenal gland and not beyond the Gerotta fascia.

T3a – the tumor spreads to the renal vein and/or its segmental branches or enters the renal collecting system or perirenal adipose tissue, but not outside the Gerotta fascia.

T3b – the tumor spreads into vena cava inferior under the diaphragm

T3c – The tumor spreads into vena cava inferior above the diaphragm or invades the wall of the vena cava.

T4 – The tumor goes beyond the Gerotta fascia or also encompasses the ipsilateral adrenal gland.

N – Regional lymph nodes

Nx – Regional lymph nodes cannot be evaluated

N0 – There is no evidence of regional lymph nodes

N1 - Metastasis in regional lymph nodes

M – Distant metastases

M0 – There are no distant metastases.

M1 – There are distant metastases

Staging according to TNM classification system is:

Stage I - T1 N0 M0

Stage II – T2 N0 M0

Stage III – T3 N0 M0

T1, T2, T3, N1 M0

Stage IV – T4, any N, M0

any T, any N, M1

Most of the cases of renal cell carcinoma are detected by accident in imaging diagnostics, usually with magnetic resonance imaging, computed tomography or ultrasound. Only 10% of patients have the "classic triad" of symptoms: hematuria, pain in the lumbar region and palpable tumor formation. Other common symptoms include fever, weight loss, and leukocytosis. About 20% of patients suffer from various paraneoplastic syndromes, such as hypercalcaemia (due to a peptide associated with parathyroid hormone), polycythemia (due to erythropoietin), Cushing's syndrome (due to adrenocorticotropic hormone) or hypertension, due to renin overproduction (Decastro et al., 2008). In its early stages, renal cell carcinoma usually has no signs or symptoms. Over time, various signs and symptoms may develop, including blood in the urine; pain in the back or lumbar region, which does not go away; loss of appetite; unexplained weight loss; fatigue and high temperature (Leibovich, 2022).

Factors that increase the risk of developing renal cell carcinoma are:

- Obesity – Excessive weight is a risk factor for both sexes. In patients with newly diagnosed renal cancer, excess body weight is associated with a lower stage and lower disease class. Paradoxically, patients with a higher body mass index have a significantly better prognosis compared to those with a smaller body index. (Choi et al., 2013).

- Smoking – one of the significant risk factors for renal cell carcinoma, similar to lung cancer and bladder cancer. Cigarette smoke contains many carcinogens such as polycyclic aromatic hydrocarbons and beta-naphthylamine, as well as the highly addictive neurotransmitter modulating substance - nicotine. As they are filtered through the nephron, these particles are metabolized, promote inflammation and induce DNA damage, paving the way for carcinogenesis (Padala et al., 2020).
- Arterial hypertension – hypertension damages the renal glomerulus and tubular apparatus and is associated with an increased risk of renal cancer. Not effectively controlled arterial hypertension significantly increases the risk of developing renal cell carcinoma (Padala et al., 2020).
- Use of analgesics in large doses that contain phenacetin. Prolonged intake of combinations of analgesics, especially compounds containing phenacetin (whose main metabolite is acetaminophen) and aspirin, can lead to chronic renal failure. Such patients are at increased risk of renal pelvic tumours and urothelial tumours. Epidemiological studies have shown an increased risk of renal cell carcinoma with long-term use of aspirin, NSAIDs (nonsteroidal anti-inflammatory drugs) and acetaminophen, although the risk may vary depending on the agent (Cho et al., 2011). Regular use of nonsteroidal anti-inflammatory drugs (without aspirin) is also associated with an increased risk of renal cell carcinoma, possibly because these agents inhibit prostaglandins, which are necessary for proper renal function (Paadala, et al., 2020).
- Undergoing long-term hemodialysis due to *"increased incidence of acquired polycystic renal disease, and this predisposes to the development of renal cell carcinoma"* (Vassileva, 2013).

- Nutrition and alcohol intake – the intake of foods that are rich in meat proteins, fats and dairy products are associated with an increased risk of renal cell carcinoma. Moderate alcohol intake has a protective effect on the development of renal cell carcinoma, while excessive intake is associated with an increased risk in both women and men (Paadala, et al., 2020).

Technological advances in recent years have led to an increase usage of technology in the field of medicine, allowing improvement in patient care. Surgery is one of the innovative industries that has seen the rapid introduction of innovative technologies (Kerray & Yule, 2021). Robotic surgery is an evolution in medicine, advances in the mini-invasive spectrum (Goh & Ali, 2022). At the beginning of the 20th century, the first cases of robotic assisted radical prostatectomy were reported using the new generation DaVinci system (Autorino & Porpiglia, 2020). Created in 1999, DaVinci system is the *"telerobotic surgical system first used by cardiac surgeons"* (Kolev, 2014), developed by Intuitive Surgical. In 2000, a Da Vinci S system was also developed, originally used for coronary surgery. Since the initial use of the DaVinci system, evidence supporting its effectiveness has steadily increased, despite debate over the high cost of using it and the need to conduct structured training for surgeons (Palagonia et al., 2019). Robot-assisted surgery has been associated with less blood loss, shorter hospital stays, fewer complications, and fewer transfusions than laparoscopic surgery for patients with endometrial cancer and complex myomectomies (Kim et al., 2017). In urology, the use of robot-assisted surgery offers solutions for open or laparoscopic procedures. The treatment of renal cell carcinoma is mainly surgical through the so-called. radical nephrectomy, in which the kidney is removed, along with the tumor (Vassilev, 2011). Robot-assisted partial nephrectomy is a safe, minimally invasive operation with excellent functional results and few perioperative complications (Ge et al., 2018). In pediatric urology, the use of robot-assisted surgery is also gaining popularity, mainly for the removal of suspected or malignant lesions of the genitourinary system (Sayari et al., 2019).

The initial experience of robot-assisted surgery in the field of urology began with robot-assisted prostatectomies for adults and was soon applied in pediatrics with robot-assisted pyeloplasty. In paediatric urology, robot-assisted surgery was subsequently reported for ureter reimplantation, ureterouterostomy, appendix language construction, bladder cervical reconstruction and augmentation ileocystoplasty. In paediatric urology, robot-assisted surgery was subsequently reported for ureter reimplantation, ureterouterostomy, construction of appendicovesicostomy, bladder cervical reconstruction and augmentation ileocystoplasty. Robot-assisted surgery is also used in performing procedures on infants, with 5 mm robotic instruments (Avery et al., 2015). Following the approval of the da Vinci system, more than 1.5 million interventions with its use were performed worldwide in 2013. (Lee, 2014), as in 2013 alone in the US *"85% of prostate cancer operations were performed with the robotic system, compared to the proportion of laparoscopic radical prostatectomies, which is only 1%"* (Kolev, 2014). Robotic surgery is particularly suitable for surgical access within the anatomically confined pelvic space, with robotic radical prostatectomy being one of the most commonly performed robotic procedures. Better perioperative outcomes of laparoscopic and open approaches to anatomically low-risk kidney tumors, following administration of robotic partial nephrectomy, are reported in a study conducted by Bravi et al. in 2021 (Bravi et al., 2021).

Main application in urology robot-assisted surgery is found for *"radical prostatectomy, nephrectomy, benign diseases, malignant diseases, donor nephrectomy, partial nephrectomy in tumors below 6 cm., pyeloplasty, radical cystectomy, retroperitoneal lymphatic dissection, etc."* (Kolev, 2014). Robotic surgery provides good results for complex benign hysterectomy, as well as endometrial cancer, where obesity and other comorbidities are common (Varghese et al., 2019).

The DaVinci system is the most complex of all surgical robotic systems, consisting of three main components – the surgical cart on the patient's side, the monitoring system and the surgical console. In the surgical trolley there are arms for controlling the camera and robotic surgical instruments. The DaVinci system is the most complex of all surgical robotic systems, consisting of three main components – the surgical cart on the patient's side, the monitoring system and the surgical console. In the surgical trolley there are arms for controlling the camera and robotic surgical instruments. The surveillance system processes the video signal from a camera and the image displayed on the surgical console and the two separate monitors for the surgical assistant. Each eyepiece of the surgical console receives a different power supply, allowing reconstruction of the internal three-dimensional view of the operative field. When using the system, the surgeon is at a distance from the patient and operates from the surgical console. Robotic instruments are controlled by the surgeon and their movements are recreated in robotic surgical instruments, reducing tremor and enhancing precision (Holloway, 2009). The surgical assistant assists by using traditional laparoscopic instruments.

II. AIM AND OBJECTIVES

1. Aim

By using prospective and retrospective analysis, to demonstrate the relevance of robot-assisted partial nephrectomy, to achieve negative surgical limits, preserved renal function, and minimal perioperative complications.

2. Objectives

1. To make a relation between the time of warm ischemia and postoperative renal function.
2. To determine the influence of negative resection lines on recurrence rates.

3. To investigate possible intra- and postoperative complications (surgical problems) when performing robot-assisted partial nephrectomy.

4. To study early oncology results after robot-assisted partial nephrectomy.

III. MATERIALS AND METHODS

For the period from January 2020 to August 2022, 218 robot-assisted kidney surgeries were performed at the department, of which:

- Radocal nephrectomy – 68.
- Nephrectomy – 15.
- Partial nephrectomy — 73.
- Nephroureterectomy — 17.
- Pieloplasty — 20.
- Ureteroplasty – 25.

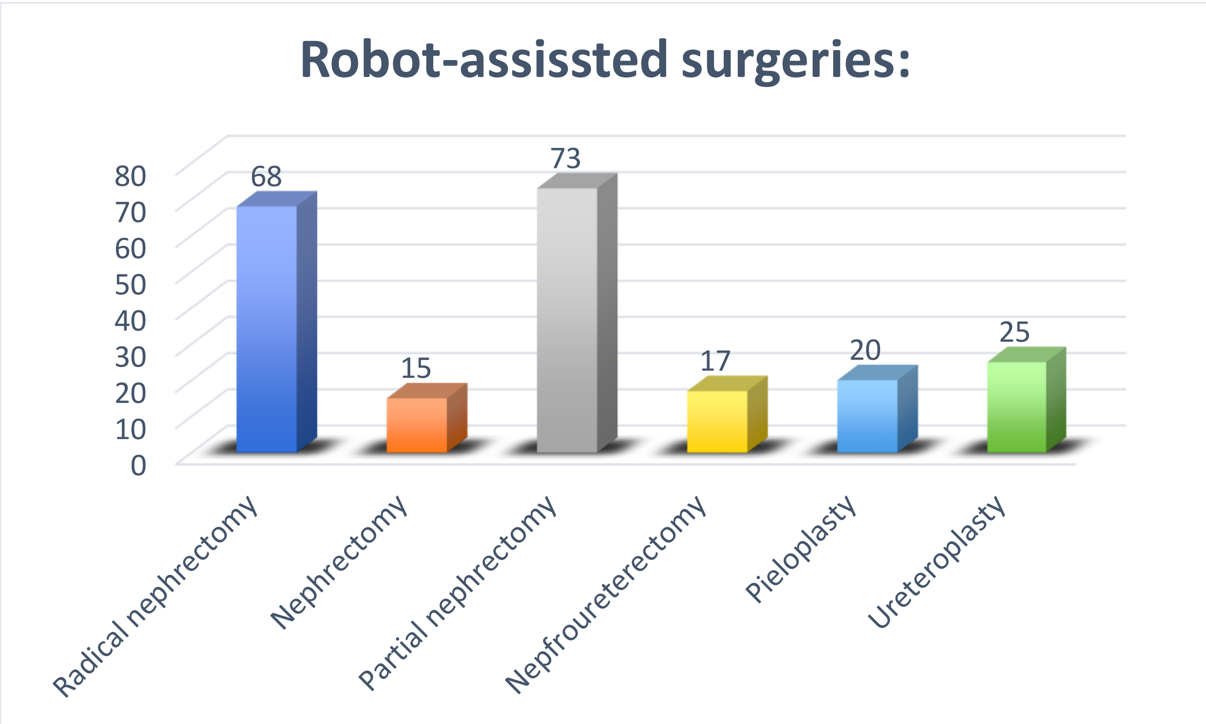

Figure 1*. Number of robot-assisted renal surgeries performed for the period 01.01.2020 – 31.08.2022*

***Table 1**. Characterization of patients with robot-assisted partial nephrectomy*

Characteristics of patients	
Men n,% Women n,%	38 (52,77%) 34 (47,22%)
Mean age	61,6(24-81)
Body mass index BMI kg/m^2	25,3 kg/m^2 (18,14-30,08)
Anesthesiological risk (ASA) 1 2 3 3-4 4	 1 (1,39%) 25 (34,72%) 41 (56,94%) 1 (1,39%) 4 (5,56%)
Median tumor size in cm, (range)	3,7
Side n,% Left Right	 36 (50%) 36 (50%)

***Table 2**. Histology*

Histology	**N(%)**
Clear RCC	42 (58,34%)
Papillary	7 (9,72%)
Chromophobe	5 (6,95%)
Oncocytoma	3 (4,17%)
Angiomyolipoma	2 (2,78%)
Multilocular cystic renal neoplasm	6 (8,34%)
Other	7 (9,72%)

Fuhrman grade	
1	23 (31,94%)
2	30 (41,67%)
3	3 (4,17) %)
4	1 (1,39%)
Other	15 (20,83%)

IV. RESULTS AND DISCUSSION

1. Analysis of preoperational data

The total number of patients with robot-assisted partial nephrectomy is 72. To determine and prove the functional results in the studied patients, a comparison was made with 73 patients undergoing laparoscopic surgery over a period of two years.

Table 3. *Total number of patients divided into groups*

145 patients studied	
72 patients with robot-assisted partial nephrectomy	73 patients with laparoscopic partial nephrectomy

. The average age of patients with laparoscopic surgery was 59.01 years, and for patients with robot-assisted partial nephrectomy was 61.60 years.

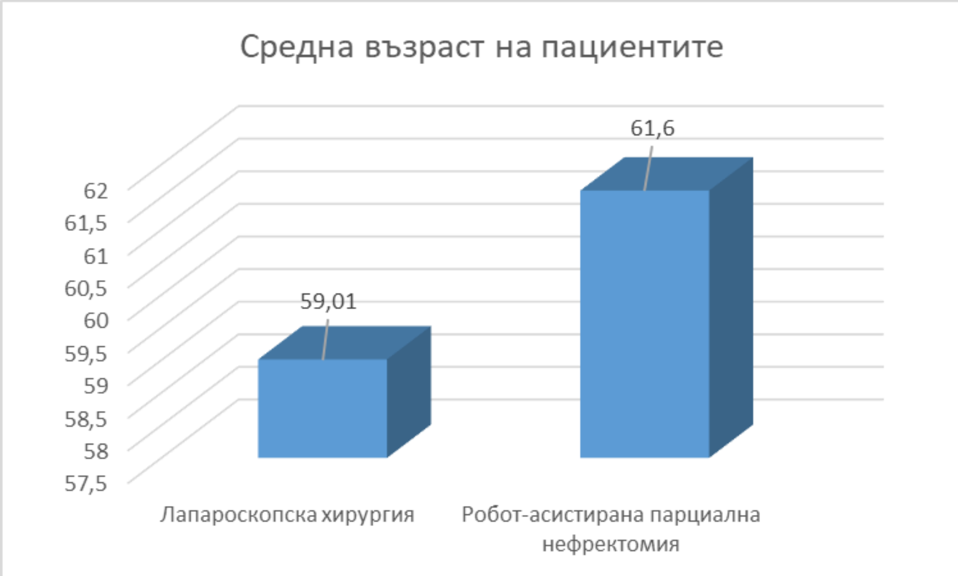

Figure 2. *Mean age of patients with laparoscopic surgery and robot-assisted partial nephrectomy*

The diagnoses of the patients are presented in Table 4.

Table 4. *Diagnosis of patients*

Diagnosis	**Number of patients with laparoscopic surgery**	**Number of patients with robot-assisted partial nephrectomy**
Tumor of the right kidney	42	36
Tumor of the left kidney	31	36

Essential surgical steps in robot-assisted partial nephrectomy that have been performed include:

1. Preparation of the kidney, preservation of fat tissue over the tumor.

2. Clamping of the renal artery.
3. Removal of the tumor.
4. Seam of the open collecting system of the kidney.
5. Parenchymal sewing.

The average time to perform surgery in robot-assisted partial nephrectomy in the studied patients was 119 minutes, while in laparoscopic surgery the average time for surgery was 138 minutes, indicating the significant increase in the time of surgery in laparoscopic surgery. The hospital stay of patients undergoing robot-assisted partial nephrectomy and laparoscopic surgery is presented in the following Table 8.

Table 5*. Hospital stay of patients*

Hospital stay (in days)	**Robot-assisted partial nephrectomy (number of patients)**	**Laparoscopic surgery (number of patients)**
3	1	1
4	37	34
5	13	9
6	9	11
7	5	10
8	4	2
Over 9	3	6

The mean hospital stay of the studied patients in robot-assisted partial nephrectomy was less than the average hospital stay in laparoscopic surgery, 5 and 6 days, respectively.

2. Oncological results

Data on the clinical stages before surgery are presented in the following table.

Table 6. *Data for the clinical T (cT) staging – robot-assisted partial nephrectomy and laparoscopic surgery*

Clinical stage	**Robot-assisted partial nephrectomy (number of patients)**	**Laparoscopic surgery (number of patients)**
T1a	31	41
T1b	26	18
T1b/ Bosniak 4	1	0
T2a	1	0
T2b	4	0
T3a	1	0
Without malignancy	8	14

As evidenced by the data in Table 6, the highest number of patients, both in robot-assisted partial nephrectomy and laparoscopic surgery, had T1a and T1b stage.

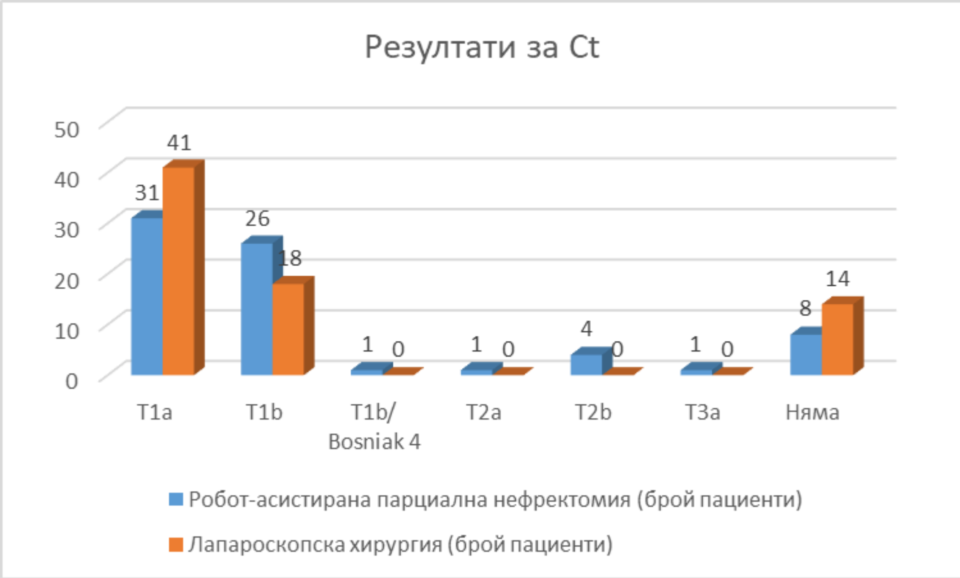

Figure 3*. Graphical presentation of cT results in patients undergoing robot-assisted partial nephrectomy and laparoscopic surgery*

The average blood loss of the 72 patients studied in robot-assisted partial nephrectomy was 148 ml. For comparison, the average blood loss in laparoscopic surgery was 239 ml. The results of blood loss found:

- Significantly less blood loss in patients undergoing robot-assisted partial nephrectomy compared to patients undergoing laparoscopic surgery.
- In 23.61% of patients with robot-assisted partial nephrectomy, blood loss was between 81 and 100 ml.
- In 20.55% of patients in laparoscopic surgery, blood loss is between 241 and 260 ml.
- None of the patients with robot-assisted partial nephrectomy lost more than 260 ml of blood.
- In 6.85% of patients in laparoscopic surgery, blood loss is between 281 and 300 ml, in 2.74% - over 300 ml, in 1.37% - over 500 ml.

Figure 4. *Comparison of blood loss in robot-assisted partial nephrectomy and laparoscopic surgery*

When comparing patients according to anesthesia risk (ASA) - 34.72% of patients with robot-assisted partial nephrectomy have an anesthesia risk ASA II, i.e. these are patients with underlying disease, but it is mild or medium that does not affect the basic vital functions. In patients with laparoscopic surgery, patients with ASA II were 36.99%. ASA III was observed in 56.94% of patients undergoing robot-assisted partial nephrectomy and in 52.05% of patients undergoing laparoscopic surgery. The indicated anesthesiological risk refers to patients who have several severe diseases, leading to disruption of vital functions and activity. Patients with ASA IV were found in 5.56% of those undergoing robot-assisted partial nephrectomy and in 8.22% of those undergoing laparoscopic surgery. In these patients, the diseases are severe, threatening their lives and the operations performed are life-threatening.

Table 7. *Comparison of stages of renal cell carcinoma in robot-assisted partial nephrectomy and in laparoscopic surgery, according to Fuhrman grade*

Stage	**Number of patients (robot-assisted partial nephrectomy)**	**Percentage of patients (robot-assisted partial nephrectomy)**	**Number of patients (laparoscopic surgery)**	**Percentage of patients (laparoscopic surgery)**
1	23	31,94%	17	23,29%
2	30	41,67%	26	35,62%
3	3	4,17%	5	6,85%
4	1	1,39%	0	0,00%
Without malignancy	15	20,83%	25	34,25%

Evident from the data presented in Table 7:

- Robot-assisted partial nephrectomy was administered to patients with a higher stage of renal cancer, namely 4.17% had stage 3, 41.67% had stage 2, 31.94% had stage 1. One of the patients undergoing robot-assisted partial nephrectomy had a renal cell carcinoma stage of 4.
- In patients undergoing laparoscopic surgery, there are none who have been diagnosed with stage 4 renal cell carcinoma. Patients with stage 3 were 6.85%, with stage 2 – 35.62%, and with stage 1 – 23.29%.

The identified complications after performing robot-assisted partial nephrectomy in the studied patients are:

- Hematoma, in the area of the hilus, treated conservatively.
- Pulmonary thromboembolism treated conservatively.

Complications after laparoscopic surgery are:

- Hematoma, measuring 51/45 mm around the right kidney; treated by placing a pig-tail drainage.
- Hematoma, measuring 58/33 mm around the right kidney; performed laparotomy, active bleeding from an arterial vessel was established and 2000 ml of blood and coagulums were evacuated.
- Hematoma, measuring about 20/21 mm; laparoscopic revision was performed, and about 700 ml of blood and coagulums were evacuated; the cause was arterial bleeding from the site of partial resection.
- Postoperative urinoma, pigtail drainage was inserted.
- Abscess in the left gluteal region, measuring 5/4 cm; incision was performed. Hematoma , measuring 70/40 mm treated conservatively.
- Positive surgical margin.

3. Functional results

The mean haemoglobin found in patients undergoing robot-assisted partial nephrectomy was 133. In 52.78% of the examined patients, the measured hemoglobin levels before surgery were between 121 and 140. The measured levels in the other patients were:

- Up to 100 – 2,78%.
- Between 101 и 120 – 16,67%.
- Between 141 и 160 – 26,39%.
- Between 161 и 180 – 1,39%.

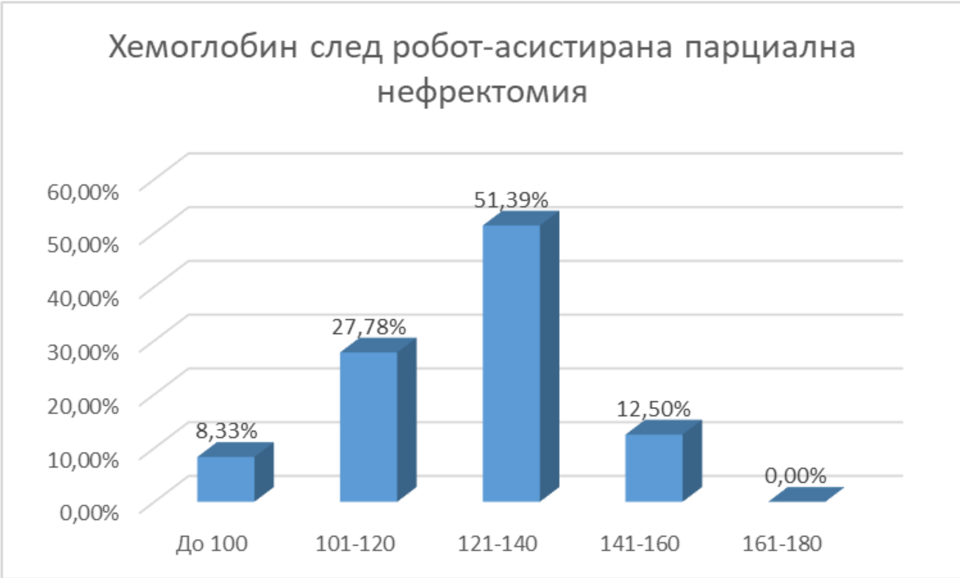

***Figure 5**. Distribution of patients after robot-assisted partial nephrectomy by measured haemoglobin levels*

Following robot-assisted partial nephrectomy, measured haemoglobin levels in patients were:

- Up to 100 – in 8.33% of patients.
- 101-120 – in 27,78%.
- 121-140 – in 51,39%.
- 141-160 – in 12,50%.

The mean measured haemoglobin in patients following robot-assisted partial nephrectomy was 123 g/L. Compared to prior to surgery, the mean haemoglobin measured was 133 g/L, due to the small blood loss resulting from the intervention. The mean haemoglobin level measured in patients undergoing laparoscopic surgery was 112 g/L, due to significantly higher blood loss compared to robot-assisted partial nephrectomy.

Table 8. *Measured haemoglobin levels in patients following laparoscopic surgery*

Haemoglobin	Number of patients
До 100	13
101-120	32
121-140	25
141-160	3
161-180	0

In 17.81% of patients undergoing laparoscopic surgery, the measured hemoglobin level was up to 100. In the other patients:

- 101-120 – in 43,84%.
- 121-140 – in 34,25%.
- 141-160 – in 4,11%.

Table 9. *Measured hemoglobin levels before and after robot-assisted partial nephrectomy and laparoscopic surgery*

Before/after surgery	Mean hemoglobin
Before robot-assisted partial nephrectomy	133
After robot-assisted partial nephrectomy	123
Before laparoscopic surgery	135
After laparoscopic surgery	112

The mean level of measured creatinine in patients before robot-assisted partial nephrectomy was 92 mmol/l. The mean level of measured creatinine in patients after robot-assisted partial nephrectomy was 90.2 mmol/l.

Table 10. Measured creatinine levels after robot-assisted partial nephrectomy

Creatinine level measured	Number of patients	Percentage of all patients
Up to 60	7	9,72%
61-80	24	33,33%
81-100	18	25,00%
101-120	10	13,89%
121-140	5	6,94%
141-160	1	1,39%
161-180	1	1,39%
Over 200	1	1,39%
No data	5	6,94%

The measured mean creatinine levels, after robot-assisted partial nephrectomy and laparoscopic surgery, are in close values

Table 11. *Measured urea values before robot-assisted partial nephrectomy and laparoscopic surgery*

Value	Number of patients before robot-assisted partial nephrectomy	Number of patients after robot-assisted partial nephrectomy	Number of patients before laparoscopic surgery	Number of patients before laparoscopic surgery
1,7-8,3	59	62	61	57
>8,3	8	5	12	16
No data	5	5		
Average	5,82	5,64	7,32	6,77

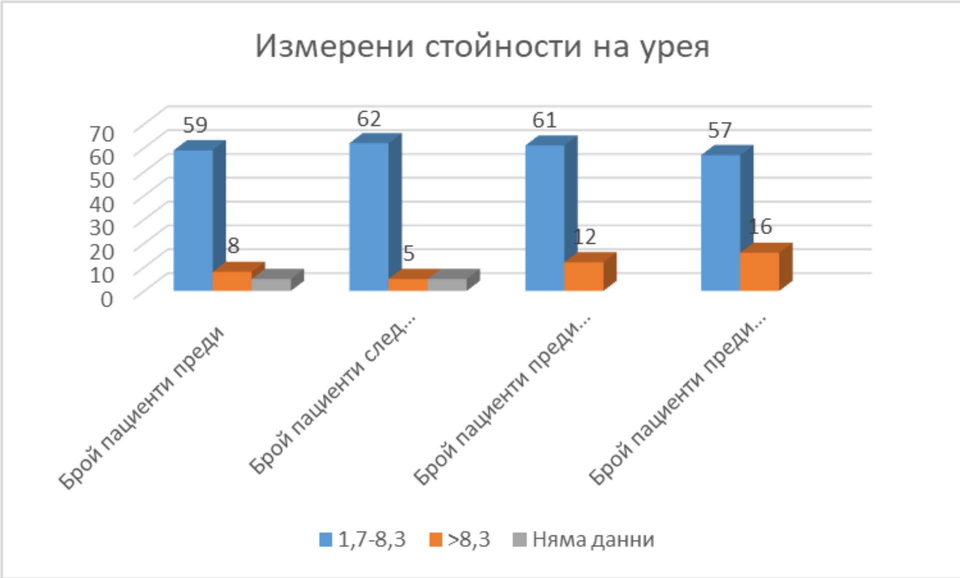

Figure 6. *Distribution of patients based on measured urea values before robot-assisted partial nephrectomy and laparoscopic surgery*

Table 12. Clamping

Time (in minutes)	**Number of patients – robot-assisted partial nephrectomy**	**Number of patients – laparoscopic surgery**
Up to 10 minutes	4	5
Up to 15 minutes	16	26
Up to 20 minutes	30	35
Up to 25 minutes	4	0
Over 25 minutes	0	1
Selective clampage up to 14 minutes	3	
No clamping	15	6
Average clamping time	14,75	17,44

The maximum clamping time of the kidney is 20 minutes, which is harmless to renal function. The data from Table 12 shows a reduced mean clamping time in robot-assisted partial nephrectomy, compared to laparoscopic surgery, respectively 14.75 min and 17.44 min. The conclusion reached is that robot-assisted partial nephrectomy allows surgery without clamping or with clamping on only one artery. An important fact for analyzing the results is that in the studied patients there is no tumor that has remained unresected. In the following Table 13, data on tumour localisation are presented in the examined patients who were given robot-assisted partial nephrectomy and laparoscopic surgery.

Table 13*. Tumor localization in the studied patients who were given robot-assisted partial nephrectomy and laparoscopic surgery*

Localization of the tumor	**Number of patients – robot-assisted partial nephrectomy**	**Number of patients – laparoscopic surgery**
LP (lower pole)	32	22
MP (Middle third)	15	25
UP (upper pole)	25	26

Evident from the data in Table 13, robot-assisted partial nephrectomy was administered to more patients with localized tumor in the lower pole, compared to laparoscopic surgery. On the other hand, laparoscopic surgery in the examined patients was applied more at the localization of the tumor in the middle pole. The application of robot-assisted partial nephrectomy and laparoscopic surgery in patients with localized tumor in the upper pole is almost the same.

With regard to tumor size, robot-assisted partial nephrectomy is found to be applicable to tumor sizes over 6-7 cm.

V. SUMMARY AND CONCLUSIONS

The improvement in imaging methods for the detection of renal lesions in recent years allows safe performance of procedures with minimal invasive techniques. As treatment methods, "*chemotherapy, radiotherapy and hormone therapy are not effective with regard to renal cancer. For surgical treatment of kidney tumors, endoscopic methods are increasingly used – laparoscopic or robot-assisted nephrectomy or partial resection"* (Vassilev, 2011). Robotic surgery provides the same benefits as laparoscopic surgery, in terms of lower pain intensity after surgery, shorter hospital stays, and a faster return of patients to normal activities, compared to open surgery. The approved Da Vinci system, introduced in 2000, includes *"three or four robotic arms manually controlled by the surgeon through a computer system located at a distance from the patient. The visualization of the operational field is accomplished by a thin video camera attached to one of the robot's arms. The remaining hands are equipped with various fine surgical instruments"* (Kolev, 2014). The instruments in the Da Vinci system have freedom of movement, which distinguishes them from those in laparoscopy. The provided freedom of movement of the instruments of robot-assisted surgery allows them to easily reach various organs in the body, which is associated with tissue damage in classical surgery (Kolev, 2014).

Robotic surgery offers a number of additional benefits associated with rapid intracorporeal suturation, administration of hemostatics within the warm period of ischemia, three-dimensional stereoscopic vision, 7° wrist movement and tremor restriction. It is mainly applicable to exophytic kidney tumors smaller than 4 cm, bilateral kidney tumors, as well as patients with a single kidney. It is contraindicated in endophytic or central renal lesions, patients with severe cardiorespiratory concomitant disease, as well as in patients with multiple previous abdominal surgeries (Stolzenburg et al., 2011).

Laparoscopic renal surgery has been associated with reduced blood loss, shorter hospital stays, and faster recovery compared to open kidney surgery (Tanagho et al., 2013). Laparoscopic partial nephrectomy was first used to treat small and peripheral kidney tumors in 1993, and since then has been widely used in clinical settings. Laparoscopic partial nephrectomy and robot-assisted surgery are minimally invasive surgical approaches that result in less bleeding, reduced postoperative pain, shorter hospital stays, and shorter patients recovery time. The limited application of laparoscopic partial nephrectomy is caused by the requirement of advanced surgical skills, has a longer learning curve and requires persistence, which limits its prevalence (Masson-Lecomte et al., 2012).

Along with the development of robotic surgery, laparoscopic surgery has also undergone significant developments over the years. Laparoscopic and robot-assisted surgery have a parallel development, which is due, on one hand, to technological innovations in medicine, and on the other hand to innovations in each of the systems. Since the first laparoscopic experience, published in 1997, there has also been a remarkable development in terms of conventional laparoscopic surgery with the introduction of HD 3D optics, special instruments for hemostasis and motorized laparoscopic instruments, for a greater degree of mobility in space. Even with conventional laparoscopy, there is a tendency to minimize the surgical approach with the introduction of minilaparoscopy and laparoscopic single-port surgery (Rassweiler & Teber, 2016).

Compared to laparoscopic surgery, robotic surgery can reduce the amount of normal parenchyma loss, resulting in the storage of nephrons and preservation of kidney function. Robot-assisted partial nephrectomy is one of the fastest growing robotic procedures in surgery, in which the oncological and functional outcomes of extirpative renal tumor therapy continue to improve (Portetzke et al., 2015). Better visualization and more precise control of the robotic surgical system facilitate the preservation of functional volume, which is a major factor in long-term renal function in patients whose ischemia time is within acceptable limits, as well as avoiding injury to vessels during resection and suturing, especially in hilar tumors that were adjacent to the main renal vessels (Chen et al., 2022). Due to the proliferation of the da Vinci system, robot-assisted partial nephrectomy is increasingly used in the treatment of small renal formations. Robot-assisted partial nephrectomy has been shown to be used in patients with a single kidney due to reliable renal function preservation, low surgical morbidity and early oncological safety (Novara et al., 2016). The advantages of minimally invasive surgery, combined with the advantages of robotic surgery, allow its use in urological surgery, in which difficult access is determined by the depth of the pelvis and small structures, which limits the use of traditional laparoscopy, in which the targeting of instruments in the desired location is hampered (Shah et al., 2014).

The change in surgical treatment goes from an open partial nephrectomy to a laparoscopic partial nephrectomy and the subsequent robot-assisted partial nephrectomy. Laparoscopic partial nephrectomy is thought to be equally effective with open partial nephrectomy, in terms of long-term functional outcomes (Gill, 2007). The main reason why laparoscopic partial nephrectomy may not be used widely enough is the technically demanding nature of the procedure.

The application of robot-assisted partial nephrectomy to renal tumors has its significant perioperative advantages, namely lower calculated blood loss and shorter warm ischemia time compared to laparoscopic partial nephrectomy. Three-dimensional visualization, improved degrees of freedom, and flexible wrists of the manipulator system are particularly suitable for facilitating tumor resection, as well as the renoraphy of a robotic system, are the basis of perioperative advantages.

Conclusions – when applying robot-assisted partial nephrectomy, it is established:

- Lack of increase in creatinine and urea values.
- Reduced blood loss.
- Ability to access more difficult places.
- Fewer complications after surgery.
- Shorter hospital stay.
- Faster recovery of patients.
- Removal of larger tumors while preserving kidney functions.
- No tumours not excised within healthy limits were identified.

VI. CONCLUSION

Worldwide, the incidence of renal cell carcinoma varies, with over 400,000 new cases and over 170,000 deaths reported annually. In 85% of diagnosed cases in adults and children, renal cell carcinoma has a relatively poor prognostic outlook without a major breakthrough in primary treatment. Renal cell carcinoma is a heterogeneous group of cancers arising from renal tubular epithelial cells that comprises 85% of all primary renal neoplasms. In most cases, renal cell carcinoma is slow in development, initially within the kidney, and it is possible to reach large sizes within 15-20 cm. Men are at higher risk group for kidney cancer than women. Globally, two-thirds of cases occur in men, with an increased risk due to variable factors such as smoking, hypertension and obesity among men. The risk of second renal cell carcinoma is increased in patients who are diagnosed and treated for kidney cancer. The risk is increased in patients who are young, therefore it is suggested that the early onset of renal cell carcinoma is due to genetic factors. Factors that promote an inherited risk of the disease are first-line relatives who have renal cell carcinoma diagnosed before the age of 40, as well as bilateral or multifocal disease. Other genetic factors are relatives with chromosomal abnormalities and additional genetic abnormalities. Patients with hereditary polycystic disease may have an increased risk of renal cell carcinoma (as well as liver and colon cancer), even in the absence of renal dysfunction or end-stage renal failure.

Due to paraneoplastic syndromes, renal cell carcinoma is difficult to diagnose. The clinical decisions that are made to carry out diagnostics are based on the symptoms of the patients and the discretion of the doctor. The overlapping histological features observed in modern practice require the use of auxiliary immunological and molecular tests to demonstrate an accurate diagnosis, which in turn has a major prognostic and therapeutic impact on renal cell carcinoma.

Along with the development of robotic surgery, laparoscopic surgery has also undergone significant developments over the years. Laparoscopic and robot-assisted surgery have a parallel development, which is due, on one hand, to technological innovations in medicine, and on the other hand to innovations in each of the systems. Robot-assisted partial nephrectomy can be performed by a transperitoneal or retroperitoneal approach. Factors that determine which approach to use include the location of the tumor, the patient's history of previous major retroperitoneal surgery or peritoneal surgery, dense perirenal inflammation/fibrosis, musculoskeletal limitations that impede proper positioning, and the surgeon's preferences. The transperitoneal approach is used more often because retroperitoneal access is more difficult, due to limited workspace and fewer anatomical landmarks. At the same time, the retroperitoneal approach avoids bowel manipulation and allows direct exposure to the renal hilus. The two approaches offer equivalent perioperative morbidity, functional and pathological outcomes, regardless of tumor location. The choice of surgical approach is determined by the location of the tumor, with the transperitoneal approach used for medial and anterior masses, and the retroperitoneal approach for the posterior

Robotic surgery offers a number of additional benefits associated with rapid intracorporeal suturation, administration of hemostatics within the warm period of ischemia, three-dimensional stereoscopic vision, 7° wrist movement and tremor restriction. It is mainly applicable to exophytic kidney tumors smaller than 4 cm, bilateral kidney tumors, as well as patients with a single kidney. It is contraindicated in endophytic or central renal lesions, patients with severe cardiorespiratory concomitant disease, as well as in patients with multiple previous abdominal operations.

VII. SCIENTIFIC CONTRIBUTIONS

The dissertation work has made several scientific contributions:

1. **Practical contributions:**
   - **The first** scientific contribution is related to the historical review of the emergence and development of robot-assisted surgery in urology.
   - **The second** scientific contribution concerns the analyzed etiology, epidemiology and pathogenesis of renal cell carcinoma and the influence of genetic and acquired risk factors.
   - **The third** scientific contribution is the presented specifics in the diagnosis of renal cell carcinoma, in terms of laboratory tests, ultrasound, radiography, computed tomography (CT) and magnetic resonance imaging.
   - **The fourth** scientific contribution concerns the deduced specifics of the types of operational access in robot-assisted partial nephrectomy.

2. **Original contribution:**
   - For the first time in Bulgaria, a study is made in the field of robot-assisted partial nephrectomy, which, using prospective and retrospective analysis, proves the importance of robot-assisted partial nephrectomy to achieve negative surgical limits, preserved renal function and minimal perioperative complications.

VIII. SCIENTIFIC PUBLICATIONS

1. Anakievski, D. Hinev, A. Kosev, P. Gocheva, I. (2017). An 18-kg giant variant of a well-differentiated retroperitoneal liposarcoma of the kidney. // Scripta Scientifica Medica// Volume. 49, No. 1, pp. 53-57
2. Anakievski, D. Hinev, A. Marinov, R. Gocheva, I. (2017). Laparoscopic nephropexy: treatment outcome and quality of life . // Scripta Scientifica Medica // Volume 49, No. 2, pp. 32-35
3. Gocheva, I. (2022) Case report: robot-assisted partial nephrectomy of renal metastasis from breast cancer with Da Vinci Xi // Varna Medical Forum// т.11, 2022