

INTRAOPERATIVE ULTRASOUND – AN INNOVATIVE APPROACH TO ASSESSING THE POSSIBILITY OF LAPAROSCOPIC PARTIAL RESECTION FOR KIDNEY TUMOURS

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Abstract

Intraoperative ultrasonography is an advanced diagnostic tool used in laparoscopic procedures for renal tumours. It helps surgeons make decisions between organ-sparing and radical surgeries by identifying small or deeply situated renal lesions and assessing the extent of resection needed for complete tumour removal while preserving kidney tissue. Additionally, it assists in evaluating the potential impact on the renal hilum or collecting system.

The primary objective of this investigation is to assess the value of intraoperative echography in the decision-making process regarding the choice of a specific surgical technique. Additionally, this study aims to understand how this decision would impact the subsequent surgical, functional, and oncologic outcomes.

A retrospective and prospective analysis was performed using intraoperative ultrasound on 27 cases involving partial kidney resection or radical nephrectomy. The study evaluated surgical outcomes, such as operative time, warm ischemia time, and blood loss. The findings revealed that 4 cases were converted from partial resection to radical nephrectomy based on intra-abdominal ultrasound findings. There are promising results regarding surgical margin integrity and the level of preserved renal function.

Intraoperative echography is a crucial tool for modern urologists, as it is linked to improved intraoperative, early postoperative, and long-term functional and oncological outcomes. It is an innovative method that combines the advantages of laparoscopic surgery with the high diagnostic value of ultrasound examination [1].

Key words: intraoperative ultrasound, renal tumour, partial nephrectomy, nephron-sparing surgery, resection margins

Introduction. Advances in ultrasound imaging technology, particularly the reduction in transducer size and improvement in resolution, have facilitated its integration into surgical procedures. Although initially utilized for intraoperative diagnosis of renal lithiasis by SCHLEGEL et al. [2], its significance grew substantially in the early 21st century. In contemporary surgical treatment for localized kidney tumours, surgeons utilize intraoperative ultrasound to obtain real-time diagnostic information. This information can significantly influence the decision-making process regarding the appropriate intervention, whether partial resection or radical nephrectomy. Placing the transducer directly on the organ's surface enhances resolution while avoiding the superimposition of bone structures and soft tissues [3]. It significantly improves the ability to identify tumours within the kidney, including tiny lesions that may not have been found during preoperative imaging. It also helps determine the depth of resection and the extent of invasion in the kidney or collector system. It preserves more normally functioning kidney tissue, reduces operating time, minimizes blood loss, and shortens warm ischemia time. These advantages of intraoperative ultrasound led to improved postoperative functional and oncological results. It is a valuable diagnostic method that supports the work of the urologist.

The importance of using intraoperative ultrasonography to plan and perform partial resection of the kidney needs to be determined. Analyzing the surgical, oncological, and functional outcomes must demonstrate the need for its use in laparoscopic partial resection of kidney tumours.

Materials and methods. The data was input and analyzed using IBM SPSS Statistics at IP address 27.0.1.0. Visual representations were generated using Microsoft Office 2021 Excel. The statistical methods employed encompassed descriptive analysis to present the frequency distribution of the studied characteristics in a tabular format. Additionally, we utilized the Fisher–Freeman–Halton exact test, Fisher's exact test, and χ^2 test to assess hypotheses concerning the relationships between categorical variables. Furthermore, correlation analysis was conducted to examine hypotheses about the presence of a linear relationship between quantitative features.

A retrospective analysis was conducted on data from intraoperative ultrasound examinations and postoperative results of 27 patients who underwent laparoscopic partial resection or radical nephrectomy at the Urology Department of Alexandrovska University Hospital from September 2023 to March 2024. In any

case, the access was transperitoneal, and a BK Medical ultrasound was used with a linear intra-abdominal transducer operating at a frequency of 4.3 MHz to 10.0 MHz.

The patients were grouped based on age, sex, affected kidney, size and location of the lesion, depth of growth in the kidney tissue, and nephrometric assessment of the tumour using PADUA & R.E.N.A.L. nephrometry scoring systems. This data was collected from preoperative CT/MRI scans. Other factors considered were operative time, warm ischemia time, blood loss, early postoperative complications, hospital stay, positive surgical margins, and functional outcomes.

The decision to perform either a partial resection of the kidney or a radical nephrectomy was based on a comparison of data obtained from intraoperative ultrasound and preoperative imaging examinations. The follow-up period for the patients is six months.



Fig. 1. Intraoperative ultrasound (BK Medical ultrasound with linear intra-abdominal transducer): The tumour is growing in the pelvicalyceal system (endophytic growth)

Results. Over seven months, the Urology Department at Alexandrovska University Hospital conducted 27 laparoscopic kidney surgeries to address solid kidney lesions using intraoperative ultrasound (Fig. 1). The study involved 17 male patients (63%) and 10 female patients (37%) with an average age of 51.8 years (Fig. 2). Among the patients, 15 had issues with their left kidney, while 12 had issues with their right kidney (Fig. 3). Before the surgery, the average tumour diameter, as observed in the CT/MRI scans, was 2.9 cm, and the average nephrometric PADUA score was 7. The average duration of the operation was 145

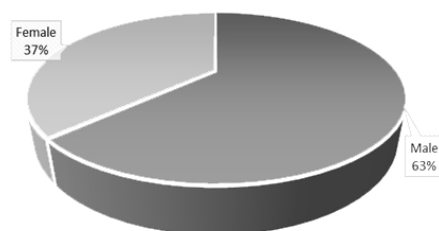


Fig. 2. Distribution of patients by gender

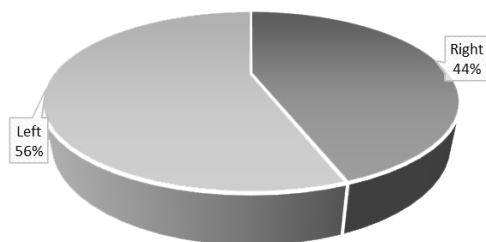


Fig. 3. Affected kidney

minutes, with an average warm ischemia time of 10.48 minutes. In twelve cases, the renal hilus was left unclamped using the “off-clamp technique”, the average blood loss was 169.6 ml (Table 1). Following an intraoperative ultrasound and assessment of the size and depth of penetration of the formation into the renal parenchyma, along with data on the involvement of the collector system and/or hilus (Fig. 1), a decision to convert to radical nephrectomy was made in four patients (14%). After the surgery, there were minimal early complications, which were minor and categorized as first-degree, according to Clavien–Dindo. These issues have resulted in mild pain and low-grade fever. Following a comprehensive pathoanatomical assessment, no positive surgical margins have existed. Histological verification confirmed clear cell renal cell carcinoma in 22 patients (81% of cases), a papillary variant of renal cell carcinoma in 2 patients (7%), angiomyolipomas in 2 patients (7%), and oncocytoma in 1 patient (3%). In patients who underwent partial kidney resection guided by intraoperative ultrasound, postoperative renal function and eGFR (Estimated Glomerular Filtration Rate) showed better results.

Discussion. The primary goal of surgical treatment for localized renal lesions is to achieve clear surgical margins, prevent local disease recurrence, and preserve as much renal tissue as possible to maintain postoperative renal function [4–6]. Thanks to advancements in imaging methods and surgical techniques, early and accurate diagnosis of kidney tumours has greatly enhanced the treatment of solid kidney lesions over the last two decades. The preferred treatment for malignant kidney diseases is surgical intervention involving partial resection

T a b l e 1

	TD [cm]	PADUA score	OT [min]	WIT [min]	Blood loss [ml]
Patient 1	3.6	8	120	17	150
Patient 2	3	7	150	23	70
Patient 3	2.5	7	170	21	100
Patient 4	2.5	6	170	26	200
Patient 5	2	8	160	0	200
Patient 6	2.5	7	120	0	200
Patient 7	2.4	8	190	14	220
Patient 8	3.4	7	175	0	180
Patient 9	2.5	9	155	12	120
Patient 10	2.6	8	150	14	150
Patient 11	2.1	7	125	0	160
Patient 12	2.5	9	145	0	170
Patient 13	4	9	130	12	100
Patient 14	3	7	170	0	200
Patient 15	4	7	160	5	250
Patient 16	3.7	7	130	0	80
Patient 17	2.5	7	160	0	250
Patient 18	4.4	6	160	0	230
Patient 19	2.6	7	165	15	250
Patient 20	3	6	130	0	180
Patient 21	2	7	90	0	150
Patient 22	1	8	160	30	140
Patient 23	3.3	7	150	25	150
Patient 24	3.3	8	125	26	120
Patient 25	3.3	10	150	26	260
Patient 26	4	6	115	17	150
Patient 27	2.7	7	90	0	150
Average	2.903704	7.407407	145	10.48148	169.6296

TD – Tumour diameter; OT – Operating time; WIT – Warm ischemia time

or radical nephrectomy using open, laparoscopic, or robotic techniques. The National Comprehensive Cancer Network (NCCN) recommends partial nephrectomy for tumours at stage T1a (tumour size ≤ 4 cm). For tumours at stage T1b (tumour size > 4 cm, but ≤ 7 cm), NCCN suggests partial resection as the preferred method, emphasizing its lower risk of causing chronic kidney disease (CKD) or worsening pre-existing CKD, along with favourable oncological outcomes such as cancer-specific survival, recurrence-free survival, and time of progression [7]. Partial resection of the kidney, a surgery that preserves the organ, is linked to quicker

recovery and improved overall survival [8]. CT and MRI are used for preoperative assessment of kidney tumours. Still, they do not provide real-time evaluation of resection depth in partial nephrectomy, which can be achieved with intraoperative ultrasound (Fig. 1). The high resolution of intra-abdominal transducers enables the detection of small renal lesions that may have been missed during preoperative imaging. It also helps identify potential involvement of the renal sinus, pelvicalyceal system, or renal vessels. This capability allows for determining the distance between the tumour and these tissues, typically in the 3–5 mm range, thus making partial resection feasible [9, 10].

The primary goal of nephron-sparing surgery for RCC is to remove the tumour completely, ensuring clear surgical margins and preserving the maximum amount of healthy, functioning tissue.

Partial nephrectomy, whether open or laparoscopic, is performed based on the “rule of the three Qs” (quality, quantity, quickness): the quality, quantity, and speed of resection. These factors are crucial for preserving postoperative renal function.

The utilization of laparoscopic partial kidney resection has yielded comparable surgical, oncological, and functional outcomes to traditional resection while offering the advantages of fewer complications, shorter hospital stays, and faster recovery. Intraoperative ultrasound is critical in locating the tumour and evaluating its growth within the renal parenchyma. It enables real-time assessment of its interaction with the collector system and involvement of the renal hilum, which helps determine the optimal surgical approach, whether it is organ-preserving or radical. This technology not only reduces intraoperative and warm ischemia times but also contributes to long-term improvements in kidney function, as evidenced by eGFR measurements and positive oncological outcomes such as clear surgical margins, recurrence-free survival, and cancer-specific survival [11]. The method provides a significant advantage for intrarenal formations. It allows for quicker identification of the resection zone in exophytic formations, leading to a reduction in warm ischemia time [10, 12]. The transducer is placed directly on the visceral surface during intraoperative ultrasound. This placement avoids interference from the layers of soft tissues, providing a clearer image and helping the surgeon focus on details that may not be captured by other imaging methods [13]. During patient follow-up, intraoperative ultrasound is a valuable tool for modern urologists, resulting in improved intraoperative, early postoperative, and long-term functional and oncological outcomes.

Conclusion. Performed intraoperatively, intra-abdominal ultrasound is a valuable and innovative method that complements the information obtained from preoperative imaging (CT/MRI), thus supporting the decision to perform a radical or organ-preserving operation [14]. It can optimize the technique to achieve clear surgical margins, leading to improved cancer treatment outcomes after partial kidney resection. This reduces recurrence rates and extends cancer-related survival

[9, 11, 14]. Intraoperative ultrasound assists in refining the resection boundaries while preserving the organ's function, leading to improved outcomes.

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