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RESEARCH ARTICLE

Laparoscopic total nephrectomy – Our local experience

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Introduction: Laparoscopic total nephrectomy (LTN) is nowadays the gold standard excision modality for both tumor and non-tumor renal pathology. With a more than 7-year presence in our department, laparoscopy is gaining more and more ground in our everyday urological practice. We aimed to analyze our experience with LTN, including learning curve analysis, in order to assess our gain in surgical experience with the new procedure.

Methods: We performed a retrospective cohort study in the Department of Urology, Mureș County Hospital and included all patients that benefited from laparoscopic total nephrectomy in the period 2017-2022. A total of 109 patients were included and their corresponding clinical and histopathological information was obtained from clinical records. Data was stratified according to patient demographics, histopathological diagnosis and operating surgeon.

Results: Age pyramid analysis revealed a predominance in male patients (62, 56,9%), whose age distribution was mostly in the intervals 60-65 (11, 10.09%) and 70-75(11, 10.09%). Most procedures were performed for tumor pathology (94, 86.2%), the most frequent histopathological diagnosis being clear cell carcinoma (71, 65.1%). Learning curve analysis was restricted to pT1 RCCs and performed for the two surgeons with the most experience for accuracy. A non-linear decrease in operative time was found for both surgeons, although not statistically significant.

Conclusion: Although limited in sample size, our study demonstrated a decreasing trend in operative time for laparoscopic total nephrectomy with the gain in experience, although inconsistent. Further studies with larger cohorts spanning on larger time intervals are necessary for a more thorough appreciation of surgical experience.

Keywords: learning curve, laparoscopy, total nephrectomy, surgical experience

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Introduction

The "learning curve" is a term borrowed in medicine from aeronautics, referring to the number of procedures a surgeon must perform for his inexperience not to further impair the outcomes of a procedure. Thus, since an increased work experience resulted in improved airplane production, the more procedures a trainee surgeon performed, the better the outcomes of the procedure [1].

Laparoscopy was introduced in the field of urology in 1991 as a procedure for treating cryptorchidism, pelvic lymphadenectomy, varicocele repair and nephrectomy [2]. With time, techniques were developed for performing partial nephrectomy, kidney reconstruction surgery, nephroureterectomy, radical cystectomy and radical prostatectomy. Although the development was inhomogeneous, laparoscopy is nowadays used on a broad scale worldwide for both diagnostic and therapeutic purpose in urology [2] . Apart from conventional laparoscopy, robot-assisted laparoscopic surgery is gaining more and more ground, together with the technical improvements and innovations [3].

Current indication for laparoscopic surgery in urology is mainly in oncologic surgery (kidney, prostate and bladder cancer) as well as non-oncologic and reconstructive surgeries (e.g. pyelolithotomy, pyeloplasty) [4].

At the Urology Department, Mureș County Hospital, in Târgu-Mureș, laparoscopic procedures started being performed in 2017, first with renal cyst fenestration/excision, varicocelectomy and then continuing to total/radical nephrectomy, partial nephrectomy, radical prostatectomy and radical cystectomy.

As surgical activity increased, we aimed to perform a thorough analysis of the laparoscopic procedures performed in the first five years of activity using learning curve analysis as a quality control parameter. Since the most common laparoscopic procedure in our department was total nephrectomy (TN) we performed a retrospective analysis of the laparoscopic total nephrectomy surgeries performed in our department.

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Methods

We performed a retrospective registry-based study from the archives of the Department of Urology, Mureș County Hospital and assessed each laparoscopic procedure starting from 2017 to 2022.

Approval was obtained from the local ethics committee for the current work, issue 4660/08.04.2022.

All surgical procedures performed in the study period were reviewed individually as well as the corresponding histopathological result (if available) from the archives of the department. We included only patients that benefited from total nephrectomy (TN) that had all data concerning the surgery available (e.g. operative time) as well as the histopathological result. Patients with other pathologies or incomplete data were not considered for the study.

Thus, we included a series of 109 patients for whom we retrieved the name, gender, operation date and time, preoperative diagnosis, name of surgeon, type of procedure, length of procedure, information on potential complications and the final histopathological diagnosis, including TNM staging (in oncologic patients). Data was further stratified according to diagnosis, as well as the individual surgeons (1,2,3 and 4). Surgeon 2 had the most clinical experience of the lot (over 20 years).

The laparoscopic total nephrectomy technique was the same in all four surgeons (pneumoperitoneum using the Veress needle, trocars insertion, hilum control with Hemolok® clips, renal excision via an iliac fossa minilaparotomy.

For learning curve analysis, to reduce biasing to the minimum, we restricted the analysis to the surgeons who performed most procedures (surgeons 1 and 2) and considered only the patients with renal cell carcinoma staged T1 (T1a and T1b).

Statistics were performed using the Jamovi software for Mac, version 2.3.28. Descriptive statistics (mean, median and standard deviation) were performed for continuous variables. After performing normality tests, the non-parametric variables were compared using the chi-square test ($p<0.05$).

Results

Patient demographics

We included a series of 109 patients that benefited from total nephrectomy in the Department of Urology, Mureș County Hospital in the period 2017-2022. The majority were men 62(56.9%) and the average age was 62. Age pyramid analysis revealed a peak at 60-65 in women (12 patients) and two peaks in men, for the 60-65 and 70-75, respectively, with 11 patients each (Figure 1).

Details on surgery

Most of the surgeries involved the right kidney (59, 54.1%). Tumor pathology was present in most cases, the majority being T1b (34, 31.2%), followed by T1a (28,25.7%) and T3a (22, 20.2%). Concerning the histopathological diagnosis, the most frequent was clear cell renal cell carcinoma (71, 65.1%), followed by urothelial carcinoma (9, 8.3%) and papillary renal carcinoma (6, 5.5%) (Table 1).

After centralizing data on duration of surgery and stratifying it according to histopathological diagnosis, the longest median operative time was for nephritis (xanthogranulomatous) (185±7.07 minutes), followed by angiomyolipoma (135), clear cell renal cell carcino-

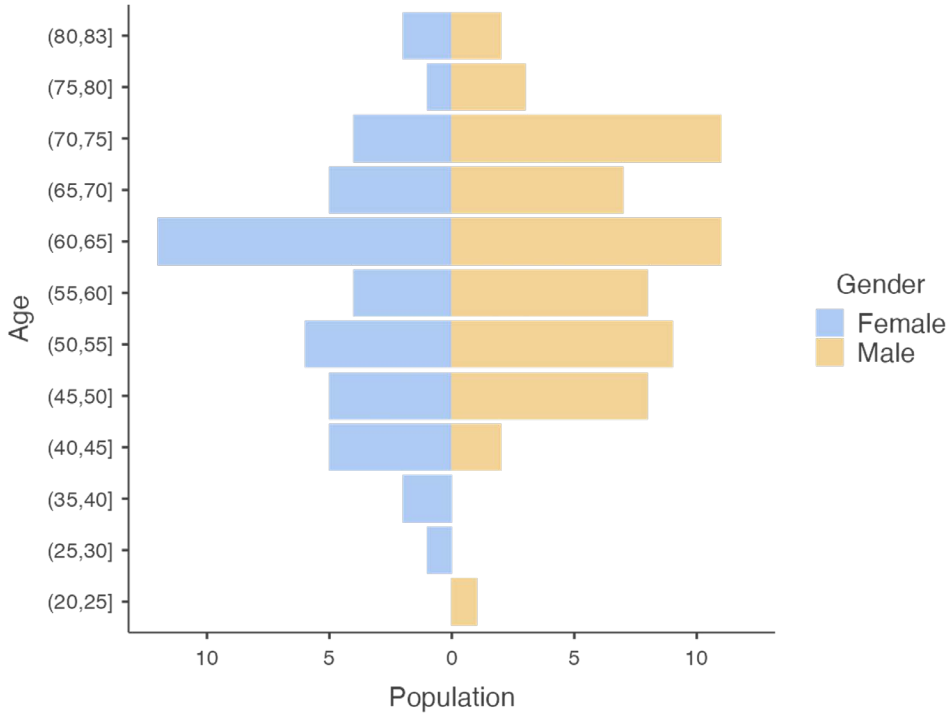

Fig. 1. Age pyramid analysis of the study patients.

Table 1. Patient demographic data and stratification according to histopathological diagnostic parameters and duration of the procedure

Characteristic	Median value or N (%)
Side of surgery	
Right side	59 (54.1%)
Left side	50 (45.9%)
Pathological results	
No tumor pathology	15 (13.8%)
T1a	28 (25.7%)
T1b	34 (31.2%)
T2a	4 (3.7%)
T2b	3 (2.8%)
T3a	22 (20.2%)
T3b	1 (0.9%)
T4	2 (1.8%)
Pathological results TN (n=115)	
Clear cell renal cell carcinoma	71 (65.1%)
Papillary renal carcinoma	6 (5.5%)
Chromophobe renal cell carcinoma	4 (3.7%)
Angiomyolipoma	1 (0.9%)
Oncocytoma	5 (4.6%)
Urothelial carcinoma	3 (2.8%)
Hydronephrosis	9 (8.3%)
Nephritis	2 (1.8%)
Pyonephrosis	3 (2.8%)
Other	5 (4.6%)
Duration of surgery	Median (minutes)±SD
Clear cell renal cell carcinoma	130±27.1
Papillary renal carcinoma	124±28.5
Chromophobe renal cell carcinoma	125±14.1
Angiomyolipoma	135
Oncocytoma	125±27.1
Urothelial carcinoma	125±16.8
Hydronephrosis	140±41.1
Nephritis	185±7.07
Pyonephrosis	140±10
Other	115±10.4

ma (130±27.1) and chromophobe renal cell carcinoma (125±14.1). (Table 1).

We further stratified the data according to the operating surgeons: Surgeon 1, surgeon2 and surgeons 3 and 4, respectively. Apart from stratifying data we also analyzed the differences between the patients of the four surgeons statistically. Thus, surgeon 2 had the most cases (68, 62.3%). He had the youngest patients of the four surgeons (median age 60±12.2) and operated more male patients (39/68, 57.3%). Both surgeons 1 and 2 operated most tumors in the T1a and T1b stages followed closely by T3a. From a histopathological point of view, most patients had clear cell carcinoma (23 cases surgeon 1, 44 cases surgeon 2, 2 cases surgeon 3 and 2 cases surgeon 4, respectively).

When analyzing the length of the surgical procedure and stratifying on surgeon and histopathological diagnosis, a statistically significant difference was found between the four surgeons ($p=0.011$, $p<0.05$). The median time/procedure was the lowest for surgeon 4, followed by surgeon 2, surgeon 3 and surgeon 1 (not statistically significant) (data not shown).

Blood loss was kept to a minimum, with an average loss of 150 ml. The hospital stay for patients not having required conversion was an average of 3.5 days.

Intraoperative complications

Conversion to open surgery was necessary in seven cases. Bleeding was the cause for conversion in three patients after the pneumoperitoneum had been successfully induced. In two cases, there was diffuse bleeding associated to poor visualization of the hilum while in the third, the cause was a direct lesion to the renal vein. Four other cases of conversion were related to complications of pneumoperitoneum induction. Thus, in one case pneumoperitoneum was impossible to obtain, in one case the adhesions were too widely spread, in one case the Veress needle entered the transverse mesocolon causing a pneumo-mesocolon and in another the Veress needle punctured the common iliac artery and required conversion and suture. Being at the beginning, for safety reasons the surgeons opted for conversion (Table 2).

Learning curve analysis

We performed learning curve analysis for both surgeon 1 and surgeon 2 in the case of T1-staged renal cell carcinoma patients. For surgeon 1, the median time of the procedure ranged from 180 minutes in 2017 to 120 minutes in 2019 and 130 minutes in 2022, with combined ascending and descending values. A non statistically-significant difference was found between values (Table 3, Figure 2).

For surgeon 2, the initial median was 158 minutes (2018), which decreased gradually to 120 minutes in 2022, although the decrease was not a constant one. The result was not statistically significant ($p=0.18$) (Table 3 Figure3).

Discussions

Overview in laparoscopic total nephrectomy

Laparoscopic radical nephrectomy is the actual standard of care for kidney cancer patients who are not eligible for partial nephrectomy and where the procedure is technically feasible. The transition from open radical nephrectomy to laparoscopic radical nephrectomy implies an increased difficulty for the treating urologist, thus requiring improved surgical experience (a learning curve) [5].

Learning curves in literature

We included a series of patients with similar proportions to the one of Pandey et al (109 versus 106) however with different gender and age proportions. Thus, Pandey et al had a cohort with a male predominance (3:1) and a mean age of 55 while the patients in our cohort had a median age of 62 and the male to female ratio was almost 1:1. Our cohorts had similar operative times (e.g. 180±26.5 minutes for total nephrectomy (surgeon 1) compared to 170±39min and 163±41min in their two groups). Although different in methodology, both studies found decreases in operative times. Our study found a decrease in the operative time for both surgeons, although not statistically significant [5].

A similar result was found in the broad review performed by Chahal et al, where they found a significant decrease ($p<0.05$) only in operative time in a single study between the first and second half of the learning curve for laparoscopic transplant nephrectomy. They further expanded the search also for hand-assisted laparoscopic nephrectomy for

Table 2. Analysis of surgery duration stratified according to surgeon and histopathological diagnosis

	Surgeon				P
	1 (n=36)	2 (n=68)	3 (n=3)	4 (n=2)	
Age	62.5±10.7	60.5±12.2	72±12.1	67±10.6	0.927
Gender					0.310
-Male	22	39	1	0	
-Female	14	29	2	2	
Side of surgery					0.538
Right side	16	40	2	1	
Left side	20	28	1	1	
Pathological results:					0.184
No tumor pathology	6	9	0	0	
T1a	9	16	1	2	
T1b	11	23	0	0	
T2a	1	3	0	0	
T2b	1	2	0	0	
T3a	7	14	1	0	
T3b	0	1	0	0	
T4	1	0	1	0	
Pathological results:					0.916*
Clear cell renal cell carcinoma	23	44	2	2	
Papillary renal cell carcinoma	2	4	0	0	
Chromophobe renal cell carcinoma	1	3	0	0	
Angiomyolipoma	0	1	0	0	
Oncocytoma	1	4	0	0	
Urothelial carcinoma	2	0	1	0	
Hydronephrosis	4	5	0	0	
Nephritis	1	1	0	0	
Pyonephrosis	1	2	0	0	
Other	1	4	0	0	
Operative time/pathological diagnosis/surgeon					P=0.011*
Clear cell renal cell carcinoma	145±25	120±26.7	133±53	115	
Papillary renal cell carcinoma	134±22.6	123±34.4	N/A	N/A	
Chromophobe renal cell carcinoma	150	120±5.77	N/A	N/A	
Angiomyolipoma	N/A	135	N/A	N/A	
Oncocytoma	125	135±30.1	N/A	N/A	
Urothelial carcinoma	134±22.6	N/A	125	N/A	
Hydronephrosis	148±17	135±53	N/A	N/A	
Nephritis	190	180	N/A	N/A	
Pyonephrosis	140	140±14.1	N/A	N/A	
Other	110	118±10.8	N/A	N/A	

* Chi square test of association

Table 3. Analysis of the "learning curve" for surgeons 1 and 2 in performing laparoscopic nephrectomy for T1 RCC tumors

Surgeon	Procedures	Year (number of cases/year) / Median length of procedure						Statistic
		2017	2018	2019	2020	2021	2022	
Surgeon 1	14	N=1 / 180	N=3 / 180±26.5	N=1 / 150	N=3 / 150±5.77	N=3 / 120±20.8	N=3 / 130±10	P=0.57*
Surgeon 2	28	-	N=4 / 158	N=9 / 170	N=6 / 145	N=4 / 120	N=5 / 130	P=0.18*

*Chi-Square test of association

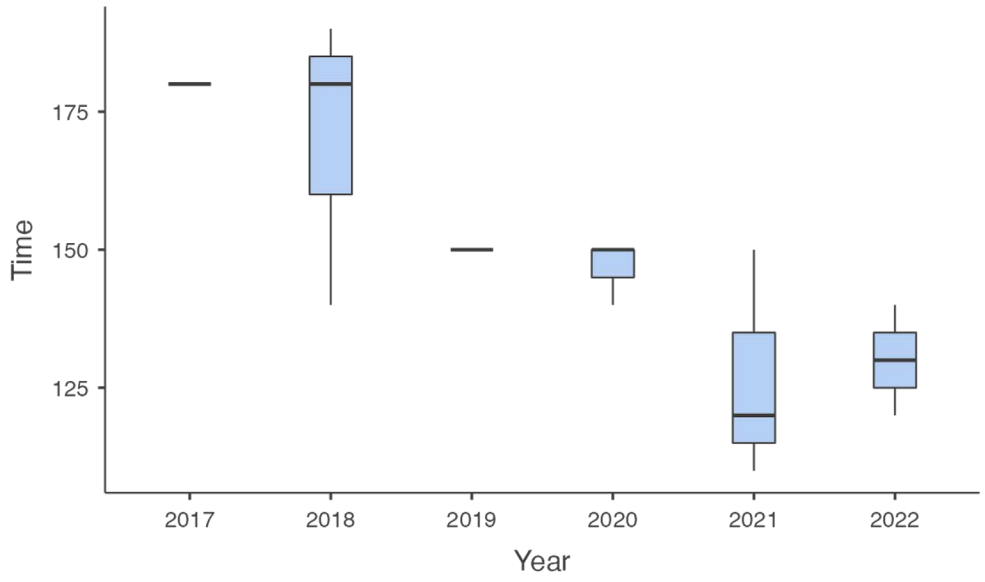

Fig. 2. Clustered bar chart illustrating median operative time for surgeon 1

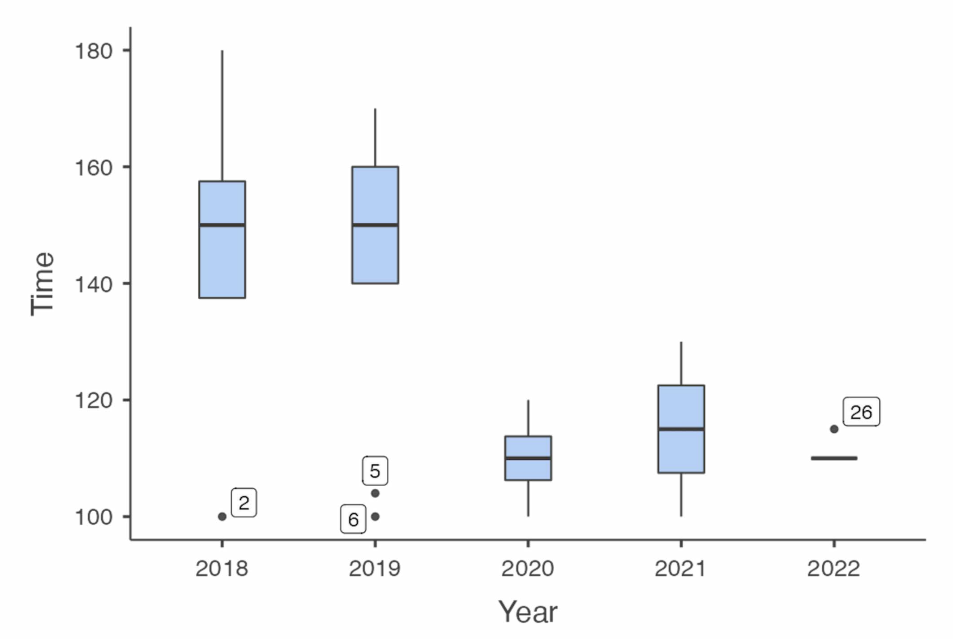

Fig. 3. Clustered bar chart illustrating median operative time for surgeon 2

transplant purposes and reported a decrease of 5 minutes or less in warm ischemia time after 40 procedures [1].

We obtained similar results as in the study of Iqbal et al where they reviewed the first 100 laparoscopic surgeries in their department. They presented a single-surgeon experience on a cohort of patients with the same male: female ratio as ours although with a lower average age. They divided the 5-year period in half, resulting in the initial period and the following one. Their analysis demonstrated a decrease in mean operative time in the second period when compared to the first one (143.82±28.36 versus 197.71±33.76 minutes) [6].

Surgical background and training

In our study, we compared the learning curves of two surgeons (referred to as Surgeon 1 and Surgeon 2) who performed the same procedure—total nephrectomy—on patients with various pathologies (e.g., kidney cancer, pyonephrosis, etc.). Both surgeons trained and practiced in different university centers, each specializing in distinct types of pathologies.

Surgeon 1 began laparoscopic training in 2016, following a three-year period of experience in open surgery after completing residency. His training included a series of practical and theoretical courses at partner university hospitals within the country. After completing these courses, he was guided intraoperatively by visiting mentors across various procedures, including total and partial nephrectomies and radical prostatectomies. Subsequently, he began performing surgeries independently with his own team.

Surgeon 2, in contrast, had a broader background in open surgery, with over a decade of experience following his residency. He also initiated laparoscopic training in 2016 and attended multiple practical and theoretical laparoscopy courses. Post-training, he performed surgeries under mentor supervision and also undertook observational visits to major laparoscopic centers abroad, where he participated in surgeries alongside local surgical teams.

The two surgeons had distinct training backgrounds and considerable surgical experience. Initially, Surgeon 1 had longer operative times. However, as both surgeons gained experience, their operative durations gradually converged toward a similar timeframe for laparoscopic total nephrectomy. This convergence likely reflects their growing expertise and the attainment of a "minimum effective operative time."

Based on our local experience, we offer the following recommendations:

– *Prior experience in open surgery is highly beneficial.* Although less frequently performed today, open surgery enhances anatomical understanding, procedural familiarity, and preparedness for managing complications.
– *Use of laparoscopic simulators (e.g., pelvi-trainers)* is strongly encouraged to improve hand-eye coordination and technical dexterity.
– *Joining established surgical teams for training*, followed by forming one's own consistent team, is essential. Continuity in team members improves coordination and familiarity with the surgeon's technique.
– *Observing surgeries in other hospitals* and collaborating with different surgical teams is valuable for gaining diverse perspectives and techniques.
– *Having a mentor during and between surgeries* is crucial—not only for guidance and teaching but also for assistance in managing complications.
– *Recording procedures and reviewing them with a mentor* in round-table discussions can significantly enhance surgical technique and decision-making.
– *We recommend a gradual approach to performing the surgery independently*—starting with staged procedures

alongside a mentor and progressing to full operations solo.
– *Perform laparoscopic procedures using a 3D camera system,* which facilitates suturing and vessel ligation—tasks that are considerably more challenging with 2D systems.

Conclusion

A decrease in procedure time was found for radical nephrectomy in T1 renal cancer patients, supporting the decrease in all total nephrectomy surgeries with the increase of experience for the surgeons in our department. Still, broader studies are necessary with larger cohorts of patients for longer periods which could further stratify information on complications, conversion rates and postoperative outcome.

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Authors' contribution

IANB: Conceptualization, data analysis, writing original draft, funding acquisition
SH: Data curation, investigation, Visualization
AL: Resources, Methodology, Supervision
CT: Visualization, formal analysis, data curation
OM: Supervision, writing review&editing, validation
CC: supervision, writing review&editing, software, validation

Conflict of interest

None to declare.

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