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The PADUA Score as a Predictor for Intraoperative Complications: A Study on Partial Nephrectomy in Open versus Laparoscopic Approach

Alexandru Iordache[1,2,3], Claudiu-Octavian Ungureanu[1,4]*, Nicoleta-Alina Mareș[1,2,5], Octav Ginghină[1,6]*, Niculae Iordache[1,4,7]

[1]Carol Davila University of Medicine and Pharmacy, Bucharest, Romania
[2]PhD Student, Doctoral School, Carol Davila University of Medicine and Pharmacy, Bucharest, Romania
[3]Department of Urology, Prof. Dr. Theodor Burghele Clinical Hospital of Urology, Bucharest, Romania
[4]Department of General Surgery, Sf. Ioan Clinical Hospital of Emergency, Bucharest, Romania
[5]Department of Obstetrics and Gynecology, Dr. I. Cantacuzino Clinical Hospital, Bucharest, Romania
[6]Department of General Surgery, Prof. Dr.Al. Trestioreanu Oncological Institute, Bucharest, Romania
[7]The Academy of Romanian Scientists, Bucharest, Romania

***Corresponding author:**
Octav Ginghină
Associate Professor, MD, PhD
Faculty of Medicine, Carol Davila University of Medicine and Pharmacy
37 Dionisie Lupu Street, Sector 2, 020021 Bucharest, Romania;
E-mail: octavginghina@gmail.com
Claudiu-Octavian Ungureanu, MD, PhD
Department of General Surgery
Sf. Ioan Clinical Hospital of Emergency
13 Vitan Barzesti Street, 042122 Bucharest, Romania
E-mail: claude.hack@gmail.com

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Rezumat

Scorul PADUA ca predictor al complicațiilor intraoperatorii în nefrectomia parțială prin abord deschis versus laparoscopic

Introducere: Scorul Preoperative Aspects and Dimensions Used for Anatomical Classification (PADUA) a fost alcătuit pe baza unui algoritm ce cuprinde caracteristicile anatomice şi dimensiunea tumorii renale, pentru a prezice riscul chirurgical şi complicațiile perioperatorii la pacienții la care s-a practicat nefrectomie parțială prin abord deschis. Pentru studiul actual, am extins aplicarea scorului PADUA la nefrectomia parțială laparoscopică şi am analizat rezultatele.

Materiale şi Metode: Studiul nostru s-a bazat pe o analiză retrospectivă a 94 de pacienți care au avut nefrectomie parțială, operați în secția de Urologie a Spitalului Clinic Prof. Th. Burghele, în perioada 2020-2024. Au fost analizate două grupuri: primul alcătuit din 44 de cazuri (54,5% bărbați) operați laparoscopic (38 prin abord transperitoneal şi 6 prin abord retroperitoneal) şi al doilea, alcătuit din 50 de cazuri (54% bărbați) operați clasic, prin abord lombar.

Rezultatele: Vârsta medie a pacienților în grupurile deschis (OPN) şi grupul laparoscopic (LPN) a fost de 64 de ani, respectiv 61,2 ani. Am analizat trei variabile în raport cu scorul PADUA: timpul de ischemie, timpul chirurgical şi indicele de masă corporală (IMC). În grupul laparoscopic, nu am găsit nicio corelație între timpul de ischemie şi timpul chirurgical (p=0,655 şi, respectiv, p=0,686). În mod similar, nu a fost observată nicio corelație în grupul deschis (p=0,882 şi, respectiv, p=0,787). Scorul PADUA a fost semnificativ corelat cu IMC în grupul laparoscopic (p=0,023), dar nu şi în grupul deschis (p=0,202). În ceea ce priveşte complicațiile, am constatat că scorul PADUA a fost semnificativ corelat cu complicațiile postoperatorii în grupul laparoscopic

(p=0,013), dar nu şi în grupul deschis (p=0,287).
Concluzie: Scorul PADUA a fost utilizat pentru a evalua complexitatea rezecției tumorii renale folosind atât abord deschis, cât şi laparoscopic. Studiul nostru a dovedit că un IMC crescut este corelat cu un scor PADUA crescut, sugerând că obezitatea poate creşte complexitatea abordului laparoscopic în nefrectomia parțială. În plus, în grupul laparoscopic, un scor PADUA ridicat s-a corelat semnificativ cu apariția complicațiilor postoperatorii.

Cuvinte cheie: scor PADUA, nefrectomie parțială, complicații, abord laparoscopic

Abstract

Introduction: The Preoperative Aspects and Dimensions Used for Anatomical Classification (PADUA) score was developed based on an algorithm incorporating anatomical characteristics and renal tumor size to predict surgical risk and perioperative complications in patients undergoing open nephrectomy. For the current study, we extended the application of the PADUA score to laparoscopic partial nephrectomy and analyzed the outcomes.
Materials and Methods: Our study was based on a retrospective analysis of 94 patients who underwent partial nephrectomy at the Urology Department of Prof. Th. Burghele Clinical Hospital between 2020 and 2024. Two groups were analyzed: the first included 44 cases (54.5% male) treated laparoscopically (38 via transperitoneal and 6 via retroperitoneal approach), and the second included 50 cases (54% male) treated with open surgery via a lumbar approach.
Results: The mean age of patients in the open (OPN) and laparoscopic (LPN) groups was 64 and 61.2 years, respectively. We analyzed three variables in relation to the PADUA score: ischemia time, operative time, and body mass index (BMI). In the laparoscopic group, no correlation was found between ischemia time and operative time (p=0.655 and p=0.686, respectively). Similarly, no correlation was observed in the open group (p=0.882 and p=0.787, respectively). The PADUA score was significantly correlated with BMI in the laparoscopic group (p=0.023), but not in the open group (p=0.202). Regarding complications, the PADUA score was significantly associated with post-operative complications in the laparoscopic group (p=0.013), but not in the open group (p=0.287).
Conclusion: The PADUA score was used to assess the complexity of renal tumor resection using both open and laparoscopic approaches. Our study demonstrated that a higher BMI is associated with a higher PADUA score, suggesting that obesity may increase the complexity of the laparoscopic approach in partial nephrectomy. Furthermore, in the laparoscopic group, a high PADUA score was significantly correlated with the occurrence of post-operative complications.

Keywords: laparoscopic, PADUA score, partial nephrectomy, complications

Introduction

In nephron sparing surgery (NSS) for renal tumors, either benign or malignant, there are two accepted techniques: open partial nephrectomy (OPN) and laparoscopic partial nephrectomy (LPN) (1,2). Robotic partial nephrectomy has gained popularity since 2004, when Gettman et al. published their first experience (3). The advantages of the laparoscopic approach are shorter postoperative recovery and smaller incision compared with the open approach (4, 5). For renal cancer, the indications for OPN and LPN are based on TNM staging (*Table 1*) (6).

Studies have shown that LPN is safe for tumors up to T3a; contraindications include thrombi in the renal vein or inferior vena cava or local tumor invasion, intense adhesions, coagulopathy, and

Table 1. TNM staging in renal tumors (6).

Tx	tumor cannot be assesed
T0	tumor not seen
T1a	tumor confined to kindney <4 cm
T1b	tumor confined to kindney >4 cm but <7 cm
T2a	tumor confined to kindney >7 cm but not>10 cm
T2b	tumor confined to kindney>10 cm
T3a	tumor grossly extending to renal vein or its segmental branches, invading pelvicalyceal system or perirenal fat but not beyond the Gerota fascia
T3b	spread to infra diaphragmatic IVC
T3c	spread to supra diaphragmatic IVC or invading the wall of the IVC
T4	involves ipsilateral adrenal gland or beyond Gerota's fascia

intolerance to pneumoperitoneum (7). Some authors, such as Abaza et al., reported successful LPN in a patient with vena cava extension of the tumor (8). Anatomic classification systems have been proposed to standardize renal tumors and to help predict the morbidity and complexity of tumor ablation (9). One of these classification systems is the PADUA (Preoperative Aspects and Dimensions Used for Anatomical Classification) score can asses the anatomical complexity of a renal mass concerning nephrectomy (10) (*Table 2*), and in the updated version Ficarra et al. proposed for partial neprectomy a Simplified PADUA Renal nephrometry system (SPARE) (11).

The objective of this study was to assess the PADUA score regarding surgical parameters, such as intraoperative surgical time and warm ischemia time, in open and laparoscopic partial nephrectomy. We also studied the relationship between the PADUA score and obesity, blood loss, surgical margins, and severity of postoperative complications in both laparoscopic and open approaches. These relationships were investigated to improve the clinical practice of partial nephrectomy.

Material and Methods

Data Collection

We retrospectively collected data from consecutive patients who underwent laparoscopic partial nephrectomy and open partial nephrectomy in the Urology Department of Prof. Th. Burghele Clinical Hospital between 2020-2024. Anatomical characteristics of the renal masses were graded preoperatively according to the PADUA classification. Patients were divided into two groups: the open group (OPN), comprising 50 patients, and the laparoscopic group (LPN), comprising 44 patients (38 transperitoneal and 6 retroperitoneal). The groups were compared for age, sex, laterality, body mass index (BMI), and PADUA score. Perioperative data included operative time, ischemia time, blood loss, perioperative complications, and surgical margins. Hospitalization time data were not compared because hospital policies have changed over time. We included patients with renal masses (either benign or malignant) with complete preoperative assessment who were suitable for partial nephrectomy. Patients with renal malformations, urinary tract infection, renal vein thrombosis, uncorrected bleeding disorder, metabolic disease associated with renal failure, and patients with incomplete data were excluded.

Table 2. Score assigned to each anatomical feature included in the preoperative aspects and dimensions used for an anatomical (PADUA) classification (10).

Anatomical features	Score
Longitudinal (polar) location	
Superior/inferior	1
Middle	2
Exophytic rate	
>50%	1
<50%	2
Endophytic	3
Renal rim	
Lateral	1
Medial	2
Renal sinus	
Not involved	1
Involved	2
Urinary collecting system	
Not involved	1
Dislocated/infiltrated	2
Tumor size (cm)	
<4	1
4,1-7	2
>7	3

Surgical Technique

Successful techniques require adequate renal hemostasis for tumor excision and reconstruction in a short time, limiting the risk of ischemia-related damage to the kidney (7). Hilar control, as well as an open approach, is one of the most important steps in LPN. Clamping the renal vessels: the warm ischemia time should be no longer than 30 min (12). In the following section, we briefly describe some particularities of the LPN technique regarding intraperitoneal and retroperitoneal approaches.

Intraperitoneal Approach

The initial step was patient positioning: modified lateral decubitus position, 45-60 degrees lateral tilt. After exploration, we performed extensive mobilization of the splenic flexure, pancreas, and spleen on the left side and Kocherization of the duodenum and exposure of the IVC on the right side. Following this mobilization, we exposed the psoas muscle by lifting the entire kidney and identifying the ureter and gonadal vein (medial below the site of dissection). Next, we dissected the renal hilum and identified the renal veins and arteries. A window superior and inferior to the vessels was created to accommodate the vascular bulldog clamps. After vascular control, excision of the tumor is the next step, usually using sharp

dissection. Haemostasis was achieved in the renal resection bed. Renorrhaphy was performed using V-loc sutures to re-approximate the renal parenchyma (also closing any collecting systems that were opened). After renorrhaphy, bulldog clamps were removed. The surgery ended with inspection of the kidney to rule out any bleeding, followed by specimen extraction and drainage.

Retroperitoneal Approach

Patient positioning implied a full 90° tilt. The retropneumoperitoneum was acquired, and the space was dissected by blunt dissection. Gerota's fascia is dissected and the peritoneum is pushed medially. The renal hilum is accessed early during dissection, which represents one of the main advantages of this approach. The entire kidney was isolated and the tumor was localized. Currently, an ultrasound probe can be used to determine the extent of the tumor and to plan excision. The artery was clamped using a bulldog clamp, and excision of the tumor was performed. The final steps were similar to those of the intraperitoneal approach described in the previous section.

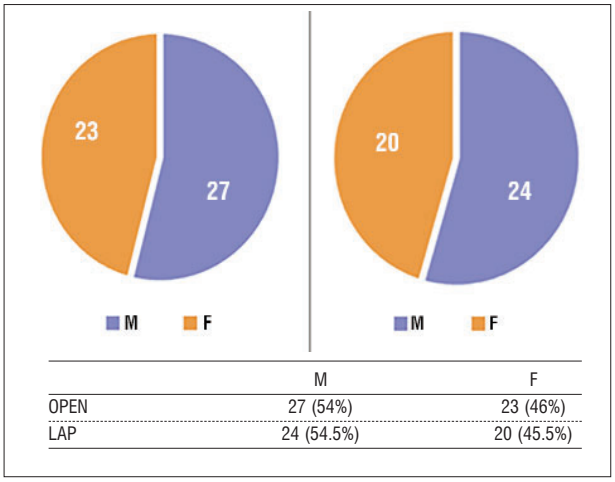
Statistical Analysis

All analyses were performed using SPSS 12.0, including chi-square tests and ANOVA. Statistical significance was set at $p < 0.05$.

Results

All 94 patients underwent partial nephrectomy (44 with LPN and 50 with OPN). Of the 44 LPN patients, 38 were transperitoneal and 6 retroperitoneal. Of these, four patients (9.09%) underwent conversion to open surgery. The mean age in the laparoscopic group was 61.20 years {41, 80}, and that in the open group was 64 years {37, 85} ($p<0.05$). Sex variable: 27% males in the open group versus 24% males in the laparoscopic group, as shown in *Fig. 1*. Regarding laterality, in the open group, 23 cases were on the right side and 27 on the left side. In the laparoscopic group, there were 23 and 21 lesions on the right and left sides, respectively (*Fig. 2*).

PADUA scores were grouped into three categories: low (6-7), medium (8-9), and high (≥10), as suggested by the original publication (1). In the open group, the mean PADUA score was 7.38 and in the laparoscopic group, it was 7.32. No significant differences were observed between the groups ($p<0.05$).

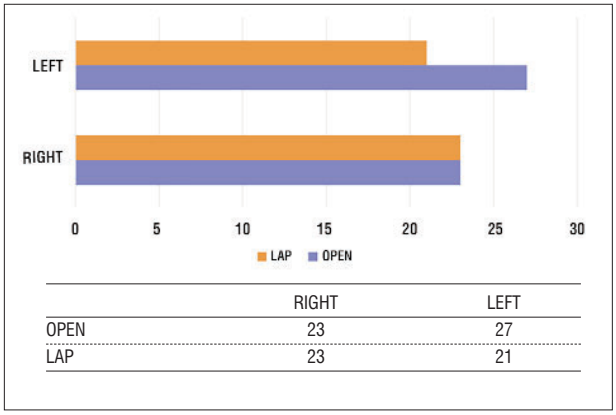


	M	F
OPEN	27 (54%)	23 (46%)
LAP	24 (54.5%)	20 (45.5%)

Figure 1. Distribution on gender – laparoscopic and open group

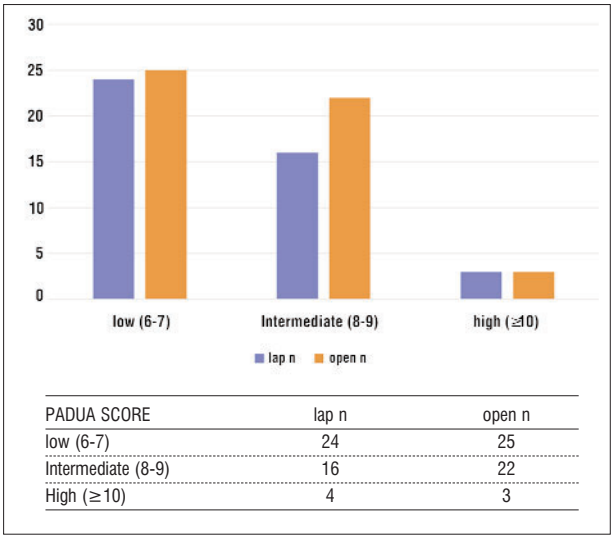
In the laparoscopic group, we found 24 cases (65.12%) with a low score, whereas in the open group, there were 25 cases (50%) with the same score. For the intermediate score, 16 cases (37.21%) were in the laparoscopic group and 22 cases (44%) were in the open group. *Fig. 3* presents data.

Some aspects that are important in partial nephrectomy are related to early and secure vascular control, limited warm ischemia time (WIT), adequate post-resection hemostasis, and renorrhaphy. Two important parameters that we studied were surgical time and ischemia time (*Fig. 4*). Our data report better surgical and ischemia times for the open approach than for the laparoscopic approach. In the open group, the mean surgical time was 146.42 min, whereas in the laparoscopic group it was 198.52 min. Regarding



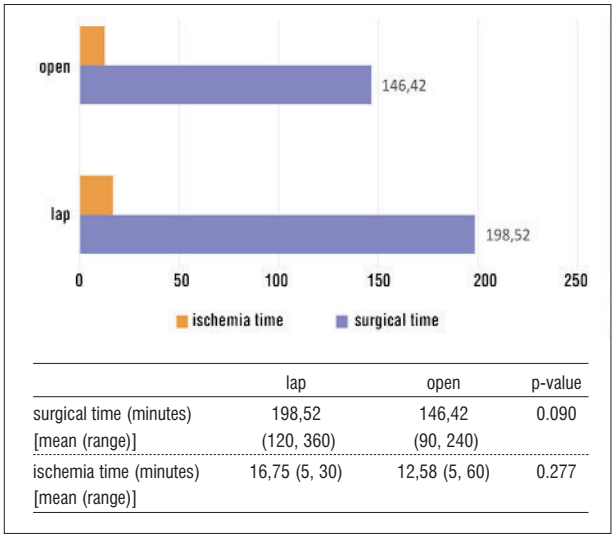
	RIGHT	LEFT
OPEN	23	27
LAP	23	21

Figure 2. Distribution on laterality – open group and laparoscopic group



PADUA SCORE	lap n	open n
low (6-7)	24	25
Intermediate (8-9)	16	22
High (≥10)	4	3

Figure 3. Distribution on PADUA score – open group and laparoscopic group



	lap	open	p-value
surgical time (minutes) [mean (range)]	198,52 (120, 360)	146,42 (90, 240)	0.090
ischemia time (minutes) [mean (range)]	16,75 (5, 30)	12,58 (5, 60)	0.277

Figure 4. Distribution of surgical time and ischemia time in both groups

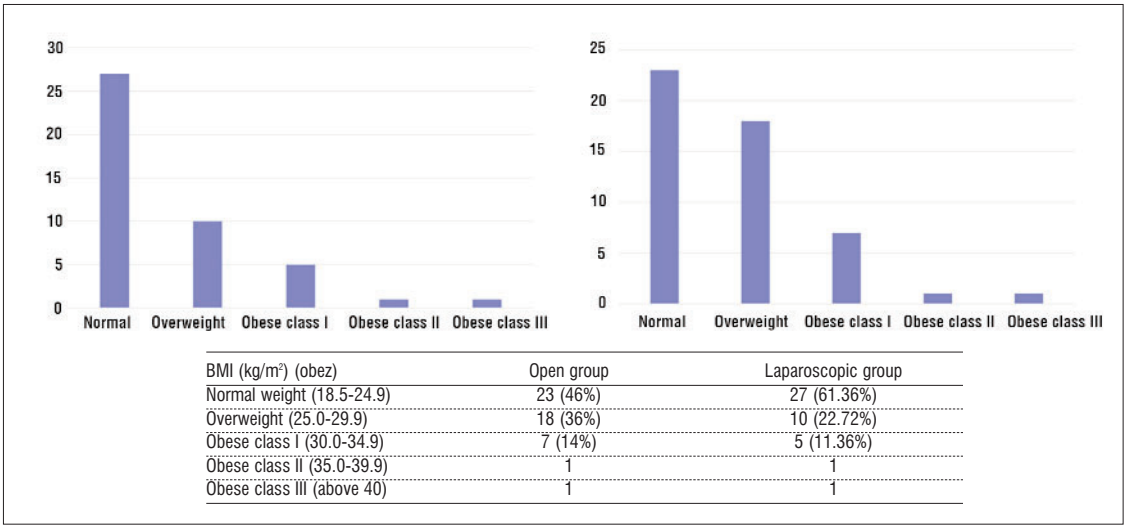
ischemia time, in the laparoscopic group, this was longer than in the open group: 16.75 min versus 12.58 min. No significant difference was observed between the groups in terms of surgical and ischemia times (p=0.090 and p=0.277, respectively).

Another characteristic analyzed was the blood loss. We observed similar operative blood loss in both groups: 282 mL for the patients included in the open group and 270.45 mL in the laparoscopic group (*Table 3*).

Another important variable was BMI. For BMI, we used the scale recommended by WHO (13). Our study showed a predominance of normal and overweight patients in both groups, with 23 cases (46%) in the open group and 27 cases (61.36%) in the laparoscopic group, all within the normal range. Obesity (classes I-III) resulted in 9 cases (18%) in the open group and 7 cases (15.9%) in the laparoscopic group. *Fig. 5* shows the data.

Table 3. Blood loss parameters on the open and laparoscopic groups

	Open group	**Laparoscopic group**
Blood loss (mL) (mean (range))	282 (100, 1000)	270.45 (150, 500)



BMI (kg/m^2) (obez)	Open group	Laparoscopic group
Normal weight (18.5-24.9)	23 (46%)	27 (61.36%)
Overweight (25.0-29.9)	18 (36%)	10 (22.72%)
Obese class I (30.0-34.9)	7 (14%)	5 (11.36%)
Obese class II (35.0-39.9)	1	1
Obese class III (above 40)	1	1

Figure 5. Distribution on BMI in open and laparoscopic group

We analyzed the PADUA score concerning ischemia time, surgical time, and BMI and found no correlation in the LPN group (p-0.47, p-0.69, respectively, p-0.63). Similar results were found in the OPN group (p-0.50, p-0.51 respectively, p-0.57). The PADUA score was significantly correlated with BMI in the laparoscopic group (p=0.023) but not in the open group (p=0.202). *Table 4* summarizes these facts.

Table 4. Correlations between PADUA score and variables in laparoscopic and open groups (Pearson correlation, level of confidence-95%)

PADUA score (open group)	Ischemia time	surgical time	BMI
p-value	0.882	0.787	0.202
PADUA score (lap group)			
p-value	0.655	0.686	0.023

Intraoperative Complications versus Postoperative Complications

In the analysis of perioperative complications related to NSS, we studied intraoperative and postoperative aspects. Intraoperatively, there were three aspects:

a. Inadequate vascular control leading to intraoperative hemorrhage (in LPN often leads to conversion to open surgery);
b. Injuries to the ureter, bowel, great vessels, pancreas, and spleen on the left side, and the liver and gallbladder on the right side;
c. Adhesions – another reason for LPN conversion to open surgery.

During the postoperative period, complications are often associated with bleeding, urine leakage, and infections. In selected cases, total nephrectomy is needed. According to the modified Clavien-Dindo scale, these postoperative complications that required nephrectomy are stated as major; the others that required conservative treatment are stated as minor complications (4). In our study, regarding intraoperative complications, in the open group, there were four cases (three cases with hemorrhage and one case with difficult adhesiolysis), whereas in the laparoscopic group, we found eight cases (66.67%); conversion to open surgery was needed (five cases due to intense adhesions and three cases due to hemorrhage).

There were fewer postoperative complications: 3 cases in the open group and 4 cases (57.14%) in the laparoscopic group. For the cases in the open group, hemorrhage (two cases) required reoperation and total nephrectomy; pionephrosis in one case also necessitated total nephrectomy (three cases of major complications). In the laparoscopic group, hemorrhage (three cases) required reoperation and total nephrectomy in two instances and transfusion in one case (two major and one minor complication). Interestingly, in the laparoscopic group, we noted one case of postoperative pain (cervical and scapular pain) that was eventually alleviated with NSAIDs. *Table 5* and *Fig. 6* show the complications.

Table 5. Intraoperative versus postoperative complications in open and laparoscopic group

Open group	
Intraoperative complications	
Difficulty due to adhesions	1
Hemorrhage	3
Postoperative complications	
Pyonephrosis	1
Hemorrhage	2
Laparoscopic group	
Intraoperative complications	
Adhesions - conversion	5
Hemorrhage	3
Postoperative complications	
Hemorrhage	3
Pain	1

According to the modified Clavien-Dindo scale, we noted three major complications for the open group and two major complications for the laparoscopic group.

We analyzed complications and found that in the open group, there was no correlation between intraoperative (p=0.380) or postoperative complications (p=0.541) and the PADUA score. In the laparoscopic group, we found no correlation between intraoperative (p=0.287) and PADUA scores; however, for postoperative complications, the score was significantly correlated (p=0.013). This probably shows that there is a clinical significance of the PADUA score in relation to

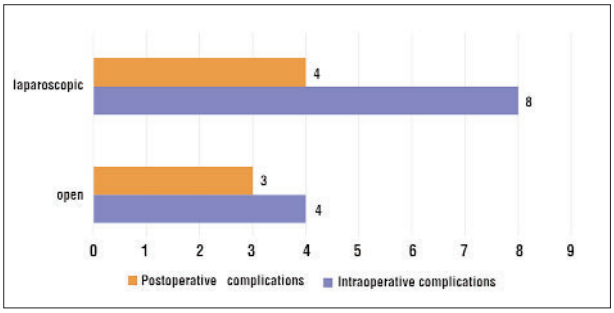


Figure 6. Intraoperative versus postoperative complications in open and laparoscopic group

laparoscopic NSS to predict postoperative complications, but this also should be interpreted cautiously.

Discussion

LPN was initially described by Winfied et al. in 1993, marking the beginning of a new era of minimally invasive NSS (14). LPN offers the advantages of shorter operative time, decreased operative blood loss, and shorter hospital stay (2). The retroperitoneal approach to LPN has the advantage of not contaminating the peritoneal cavity with blood or urine. In a study of 110 patients operated via the retroperitoneal approach, Pyo et al. reported a complication rate of 4.5% and conversion rate to open surgery in two cases and laparoscopic radical nephrectomy in four cases (15).

This approach is beneficial in multiple-operated patients with intense adhesions where intraperitoneal access would have been difficult. Difficulties with the retroperitoneal approach include limited working space, problems with delineating anatomy in previous renal surgery/infections, or obese patients. Its superiority has been proven in posteriorly located masses (16). A comparative study comparing 32 retroperitoneal versus 19 transperitoneal partial nephrectomies showed an advantage for the retroperitoneal approach, with significantly less operative time and blood loss than the transperitoneal approach; ischemia time did not differ between the two groups. The selection criteria for the retroperitoneal approach yielded these results, and the authors concluded that the decision on the approach should be based on tumor location on the kidney surface: polar/posterolateral masses for the retroperitoneal approach and anterior/medial masses for the transperitoneal approach (16).

Weizer et al. recommended a tailored approach based on tumor location and proximity to the renal sinus collecting system in LPN. They concluded that it can limit operative and ischemia times and technically simplify the procedure (17). Of the 44 LPN patients in our study, 38 (86.36%) were transperitoneal and 6 were retroperitoneal. Of these, conversion to open surgery was needed in 8 patients (18.18 %) (5 cases due to intense adhesions and 3 cases due to hemorrhage). Among the morphometry scores that describe features of renal tumors, (Radius Endophytic/exophytic Nearness Anterior posterior Location) and PADUA Score are routinely used, but some authors recommend modifications to improve and simplify these scores (18). Ficarra et al. proposed a Simplified PADUA Renal nephrometry system (SPARE) for partial nephrectomy (11).

The PADUA and RENAL nephrometry scores can influence the surgical treatment strategy for localized renal masses that can undergo partial nephrectomy (19). The purpose of using such scores is to achieve Trifecta outcomes: negative surgical margins, warm ischemia time <30 min, and minimal postoperative complications (Clavien-Dindo Grade 0-2) (20).

High RENAL and PADUA scores increased the likelihood of choosing an open NSS. However, the predictive value of these scoring systems in predicting perioperative outcomes remains controversial (21). In our study, PADUA scores were grouped into three categories: low (6–7), medium (8–9), and high (≥10). In the OPN group, there were 25 cases (50%) with a low score, with a mean PADUA score of 7.38 and in the laparoscopic group, we found 24 cases (65.12%) with a low score, with a mean PADUA score of 7.32. No significant difference was found between groups ($p<0.05$).

Key points of partial nephrectomy are related to early and secure vascular control, limited warm ischemia time (WIT), adequate post-resection hemostasis, and renorrhaphy. To analyze these aspects, we studied three characteristics related to surgery: operative time, ischemia time, and blood loss. In terms of operative duration, our study found that the mean surgical time was 146.42 minutes for the OPN group, while it was longer in the LPN group, averaging 198.52 minutes.

Additionally, ischemia time was longer in the LPN group compared to the OPN group, with values of 16.75 minutes and 12.58 minutes, respectively. No significant difference was observed between groups regarding surgical time and ischemia time ($p=0.090$, $p=0.277$, respectively). Gill et al. presented similar results, with ischemia time being higher and increasing the risk of postoperative complications (22). In an observational study of 280 patients with OPN and LPN, the authors concluded that LPN had a longer ischemia time, but the overall results between the two groups were similar (23). Ghavimi et al. reached similar conclusions (24).

No correlation was observed between the PADUA score and either ischemia time or surgical duration in both groups (LPN: $p=0.47$ and $p=0.69$; OPN: $p=0.50$ and $p=0.57$, respectively). Some studies showed similar results to our study (25,26), whereas others found a correlation between the

PADUA score and the surgical time and ischemia time (27,28). However, one aspect that was not considered is the surgeon's expertise, which can influence this correlation.

Operative blood loss was similar in both groups: 282 mL for the patients included in the open group and 270.45 mL in the laparoscopic group. Sharma et al. advocate for the same result, with less estimated blood loss for the laparoscopic approach compared to the open approach, and a significant decrease in postoperative complications at 30 days was achieved for the laparoscopic approach (29).

Obesity is associated with an increased risk of developing renal cancer; similarly, it is associated with increased risk of chronic renal disease (30-32). Obesity is known to increase the complexity of surgery and complications due to excess adiposity, obscuring anatomy, and adherent perirenal fat (33).

Obesity is a modern condition with many clinical, molecular, and psychological effects. Over the past decade, its prevalence has doubled, along with a growing trend of onset at younger ages (34).

The laparoscopic approach has advantages over open surgery in terms of healing and wound morbidity in obese patients. Moreover, an open approach can increase hospital stay and infection rates (35).

BMI yielded interesting results. Most of the patients in both groups were included in the standard and overweight categories, with few cases in the obesity categories (for the OPN group 9 patients -18% were included in the obesity class I-III, whereas for the LPN group, 7 patients (15.9 %) were included in the same classes). We found that the PADUA score was significantly correlated with BMI in the laparoscopic group ($p = 0.023$) but not in the open group ($p = 0.202$). These data suggest that one would choose the laparoscopic approach over the open approach in overweight patients with complex tumors.

Regarding intraoperative complications, four cases were recorded in the OPN group (three involving hemorrhage and one due to challenging adhesiolysis) while in the LPN group, eight cases required conversion to open surgery, prompted by intense adhesions in five cases and hemorrhage in three. There were fewer postoperative complications: 3 cases in the OPN group and 4 cases in the LPN group. For the cases in the open group, hemorrhage (2 cases) needed reoperation and total nephrectomy; pyonephrosis in one case also necessitated total nephrectomy. In the LPN group, hemorrhage (3 cases) required reoperation and total nephrectomy in two instances and transfusion in one case. Additionally, in the LPN group, we noted one case of postoperative pain (cervical and scapular pain) that was eventually alleviated with NSAIDs.

In the OPN group, there was no correlation between intraoperative ($p=0.380$) or postoperative complications ($p=0.541$) and the PADUA score. In the LPN group, we found no correlation between intraoperative ($p=0.287$) and PADUA scores; however, for postoperative complications, the score was significantly correlated ($p=0.013$). This suggests that when the PADUA score increases, the laparoscopic approach can lead to more postoperative complications. Similar results have been documented in other studies. For instance, in a study of 1800 consecutive open or laparoscopic nephrectomies (771 laparoscopic and 1028 open), equivalent functional and early oncological outcomes were achieved. Intraoperative complications were comparable, but in the laparoscopic group, a longer ischemia time was reported, and more postoperative complications were reported compared to the open group (22). This may once again be attributed to the surgeon's level of expertise. The learning curve plays a crucial role in minimizing complications, and Zimmermann et al. emphasized that experienced surgeons are associated with a lower risk of adverse events, achieving laparoscopic outcomes comparable to those of open surgery (36).

Prognostic scores are essential for accurate and individualized management, just as personalized medicine in oncology aims to dynamically tailor treatment to each patient's specific characteristics, from the time of diagnosis through to the completion of therapy (37).

Negative surgical margins are one of the aspects required to obtain the Trifecta desiderata. Interestingly, the incidence of positive surgical margins ranges widely and is generally independent of the surgical technique employed. Patients with positive surgical margins (PSM) can experience local recurrence, but there is little data on its impact on cancer-specific survival (38-40). In our study, the PADUA score was not significantly correlated to PSM in both groups ($p=0.100$). A systematic review of 8095 patients with LPN and OPN yielded similar outcomes between LPN and OPN, with significantly less blood loss ($p<0.00001$) but higher positive surgical margins ($p=0.005$) in the LPN group. There was no statistical difference between LPN and OPN in terms of operative time ($p=0.13$), intraoperative complications ($p=0.94$), and cancer-specific survival ($p=0.72$) (41).

PSM was not relevant in our study, but the

higher values compared to the literature can probably be explained by different surgeons with less experience. Moreover, certain studies have indicated a higher incidence of positive surgical margins (PSM) associated with the laparoscopic approach (42,43). The prognostic significance of PSM is debatable; follow-up data in large populations show that many patients with PSMs do not experience local or distant tumor recurrence (44). A future study will use the updated PADUA score (SPARE) in relation to perioperative variables for the open and laparoscopic approaches. Recent data regarding the robotic approach and successful use of the SPARE score seem to be superior to those obtained using open or laparoscopic techniques (45).

Conclusions

The surgical approach considerably impacts the clinical outcome in renal tumor management. Multiple scores were used to predict the operative outcomes based on various parameters. The PADUA score was used to assess the complexity of renal tumor ablation in both open and laparoscopic partial nephrectomy. We concluded that in the laparoscopic group, a high PADUA score was significantly correlated with postoperative complications. Similarly, a high BMI was correlated with a high PADUA score, indicating that obesity can increase the complexity of laparoscopic surgery in partial nephrectomy.

The laparoscopic approach has multiple advantages, but is dependent on the surgeon's expertise. Operative blood loss is lower in the minimally invasive technique, but with a higher risk of local recurrence due to more positive surgical margins. Moreover, due to the inherent complexity of the laparoscopic approach, both ischemia time and operative duration were longer. However, these parameters did not correlate with the PADUA score, suggesting the presence of additional confounding factors that warrant further investigation.

Limitations

One limitation is related to the retrospective nature of the study, which limited the strength of the results. We also note that there is a different expertise among surgeons due to the learning curve, which can influence the presented results. Finally, there was a bias related to the choice of approach for the surgeon and patient.

Author's Contributions

Conceptualization, A.I. and CO.U. Data curation N.I. and N.A.M., Resources, A.I and O.G. Supervision, O.G. and N.I. Writing – original draft and editing, A.I and CO.U. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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Informed Consent Statement

This study was conducted following the ethical principles of the latest version of the Declaration of Helsinki. Patient confidentiality was ensured.

Data Availability Statement

The data supporting the findings of this study are available per request.

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