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Impact of Surgical Method and Renal Nephrometry Score on Perioperative Results of Minimally Invasive Partial Nephrectomies

Minimal İnvaziv Parsiyel Nefrektomilerin Perioperatif Sonuçlarında Cerrahi Yöntem ve Renal Nefrometri Skorunun Etkisi

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ABSTRACT Objective: Partial nephrectomy (PN) is the optimal surgical treatment for localised renal tumors. In addition, minimally invasive PN methods are preferred more due to the superior aspects to open surgery, The aim of this study was to compare the perioperative outcomes of robotic partial nephrectomy (RPN) and laparoscopic partial nephrectomy (LPN), performed by a single surgeon, according to the surgical method and RENAL nephrometry score (RNS). **Material and Methods:** In our study, the records of patients who underwent PN between August 2009 and December 2016 at our hospital were reviewed retrospectively. Warm ischemia time (WIT) (min), operative time (OT) (min) and estimated blood loss (EBL) (cc) were evaluated as perioperative parameters. Patients were divided into groups according to surgical method as LPN group (n=30) and RPN group (n=30), and RNS [RNS<7 (n=44), Group A and RNS≥7 (n=16), Group B] regardless of the surgical method, and the perioperative values were compared. **Results:** There were no statistically significant differences in patient and tumor characteristics between the groups. There was no statistically significant difference in RNS between LPN and RPN groups. WIT, OT and EBL were statistically lower in RPN when compared to LPN and in Group A when compared with Group B. **Conclusion:** Robot-assisted surgical approach is an effective alternative method for perioperative parameters to pure laparoscopy for PN. Nevertheless, surgeons' choice of surgical methods that they have experienced will enable them to achieve clinically satisfactory results. Low tumor complexity in RNS is associated with less EBL, shorter OT and WIT in partial nephrectomies.

Keywords: Nephrectomy; laparoscopy; robotic surgical procedures

ÖZET Amaç: Lokalize böbrek tümörlerinde parsiyel nefrektomi (PN) ideal cerrahi tedavidir. Ek olarak, açık cerrahiye olan üstün yanlarından dolayı minimal invaziv PN yöntemleri daha fazla tercih edilmektedir. Bu çalışmanın amacı, tek cerrah tarafından gerçekleştirilmiş olan robotik parsiyel nefrektomi (RPN) ve laparoskopik parsiyel nefrektomi (LPN)lerde, cerrahi yöntem ve RENAL nefrometri skoru (RNS)'na göre perioperatif sonuçları karşılaştırmaktır. **Gereç ve Yöntemler:** Çalışmamızda, hastanemizde Ağustos 2009-Aralık 2016 tarihleri arasında PN yapılan hastaların kayıtları retrospektif olarak incelenmiştir. Sıcak iskemi zamanı [warm ischemia time (WIT)], operasyon zamanı [operative time (OT)] ve tahmini kan kaybı [estimated blood loss (EBL)] perioperatif parametreler olarak değerlendirilmiştir. Hastalar, cerrahi yönteme göre LPN grubu (n=30) ve RPN grubu (n=30) ve ayrıca cerrahi yönteme bakılmaksızın RNS'ye göre Grup A (RNS<7, n=44) ve Grup B (RNS≥7, n=16) olarak ayrılmış, perioperatif değerler karşılaştırılmıştır. **Bulgular:** Hasta ve tümör özellikleri açısından gruplar arasında istatistiksel farklılık gözlenmemiştir. LPN ve RPN grupları arasında RNS açısından istatistiksel farklılık gözlenmemiştir. WIT, OT ve EBL parametreleri, LPN grubuna göre RPN grubunda ve Grup A'ya göre Grup B'de istatistiksel olarak daha düşük saptanmıştır. **Sonuç:** PN'de robot yardımlı cerrahi yaklaşım, perioperatif sonuçlar açısından pür laparoskopiye alternatif olan etkili bir yöntemdir. Bununla birlikte, cerrahların tecrübeli oldukları cerrahi yöntemi seçmeleri, klinik olarak tatmin edici sonuçlar elde etmeyi sağlayacaktır. RNS'de düşük tümör kompleksliği, PN'lerde daha az EBL, daha kısa OT ve WIT ile ilişkilidir.

Anahtar Kelimeler: Nefrektomi; laparoskopi; robotik cerrahi prosedürler

Partial nephrectomy (PN) is considered to be the gold standard treatment for small and localised renal tumors. In parallel with technological advancements and improvements in operators' skills, surgeons prefer minimally invasive PN instead of open surgery.[1-3] However, it is well known that pure laparoscopic par-

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tial nephrectomy (LPN), which has a long learning curve, is a challenging procedure due to the need for meticulous tumor resection and time-dependent renal reconstruction.[2,4,5]

Robotic partial nephrectomy (RPN) is a viable alternative found to reduce technical difficulties of LPN. Thanks to the enhanced three-dimensional visualisation of da Vinci® robotic system and the excellent articulated motion of instruments, tumor resection, and renal reconstruction can be performed much more easily, reducing the warm ischemia time and giving at least similar results with LPN in terms of perioperative results.[6-9] However, it is still a controversial issue which one of the RPN and LPN is superior to the other, based on the operative and oncologic results. In recent studies and meta-analyses, variable results have been found.[2,3,5,10-14]

RENAL nephrometry score (RNS) was described to quantify renal tumor anatomy and to determine tumor complexity.[15] This study aimed to compare the perioperative results of first 30 RPN and 30 LPN cases performed by a single surgeon based on the surgical method and RENAL nephrometry score.

MATERIAL AND METHODS

This study was conducted in accordance with the Helsinki Declaration Principles and ethics commitee approval was received from the Ethics Commitee of the University of Health Sciences, Bakirkoy Dr. Sadi Konuk Training and Research Hospital for this study (2017/41). In this study, the records of the patients who underwent PN operation between August 2009 and December 2016 at our center were retrospectively analyzed by using the medical record system. Among the 132 patients obtained, the patients who underwent open surgery, had multiple renal tumors, had their tumors excised without ischemia and patients whose information could not be retrieved were excluded from the study. In conclusion, 30 laparoscopic partial nephrectomy (LPN) and 30 robot-assisted laparoscopic partial nephrectomy (RPN) cases were enrolled in the study.

Age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) score, tumor side, polar location in the kidney (upper, middle, lower pole), location at the anterior-posterior side and tumor size (cm) of the patients were retrospectively scanned and noted prior to surgery. Warm ischemia time (WIT) (min), operative time (OT) (min) and estimated blood loss (EBL) (ml) were recorded as perioperative values. RNS was used to characterize tumor complexity. RNS in every renal tumor was individually calculated by contrast-enhanced abdominal CT or MRI scans preoperatively and reaffirmed by at least 2 urologists who are familiar with this classification. The patients were divided into two groups, those with a total score of <7 and ≥7 according to RNS.

Patients were grouped as LPN Group (n = 30) and RPN Group (n = 30) according to the surgical method and as Group A (n=44) with a score of <7 and Group B (n=16) with a score of ≥7 according to RNS, regardless of the surgical method, and their perioperative values were compared.

SURGICAL METHODS

All of the patients included in the study were operated by a single surgeon (V.T.), and these cases were the first 30 laparoscopic and 30 robotic partial nephrectomy operations after the surgeon exceeded the laparoscopic and robotic surgical learning curve in operations other than partial nephrectomy. Surgical methods were explained to the patients in detail and which surgical method will be applied is determined by patients' choice.

All LPN operations were performed in a flank position by using 3 or 4 laparoscopic ports. All RPN operations were performed by using the da Vinci® Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA) and 3 or 4 robotic ports and an assistant port in a flank position.

All operations of the study were performed with a transperitoneal approach. The renal artery was closed with a laparoscopic bulldog clamp. Tumor excision was performed with the help of cold scissors. When the collecting system was opened during the excision, this area was repaired with an absorbable suture, similarly with open surgery. Tumor base repair was performed with 3-0 V-LocTM and the arterial clamp was removed in the early stage after tumor

base repair. Parenchymal repair was performed with 1-0 Vicryl® and Hem-o-lock clips by using sliding-clip technique and Surgicel® was inserted between parenchyma and suture. A drain was inserted to all patients at the end of the operation.

STATISTICAL METHOD

Descriptive data statistics were expressed as mean, standard deviation, median, highest and lowest values, frequency, and ratio. The distribution of the variables was measured by the Kolmogorov Smirnov test. Mann-Whitney U test was used in the analysis of quantitative independent data. Chi-square test was used to analyze independent qualitative data. SPSS software (Version 22.0) was used for analyses.

RESULTS

COMPARISON ACCORDING TO SURGICAL METHOD

The median age was 52.5 ± 13.4 and 50.2 ± 12.5 years in the LPN and RPN groups, respectively. The mean BMI was found to be 27.0 ± 3.7 kg/m^2 and 27.3 ± 3.4 kg/m^2, respectively. In both groups, there were no statistically significant differences in age, sex, BMI and ASA scores of the patients (p>0.05). In the LPN and RPN groups, the tumor size (cm) was 3.3 ± 1.5 and 3.5 ± 1.3, respectively. In both groups, there were no statistically significant differences in tumor size, the kidney side with tumor location, the pole with tumor location and the anterior/posterior location in the kidney (p> 0.05). In the LPN and RPN groups, mean RNS was 5.5 and 5.7, respectively. No statistically significant difference was found in RNS between the groups (p>0.05) (Table 1).

Perioperative EBL (ml) was found to be 246.8 ± 72.3 in the LPN Group and 206.0 ± 94.4 in the RPN Group. OT (min) was found to be 230.3 ± 22.2 in LPN Group and 194.5 ± 44.7 in RPN Group. WIT (min) was found to be 19.2 ± 3.8 in LPN Group and 16.2 ± 3.9 in RPN Group. Perioperative EBL, OT, and WIT were found to be significantly lower in RPN Group (p<0.05). During the tumor resection, the collecting system entry occurred in 7 patients (23.3%) in the LPN Group while it occurred in 3 patients (10%) in the RPN Group. In both groups, no statistically significant difference was observed in the collecting system entry (p>0.05) (Table 2). Also, surgical margins were negative for all patients in both group.

TABLE 1: Preoperative characteristics of the patients and tumors according to surgical method.

		LPN		RPN		
		Mean±s.d./n-%	Median	Mean±s.d./n-%	Median	p
Age, years		52.5 ± 13.4	49.5	50.2 ± 12.5	50.5	0.631
Sex	Male	17 56.7%		21 70.0%	0.284	
	Female	13 43.3%		9 30.0%		
BMI		27.0 ± 3.7	27.5	27.3 ± 3.4	26.5	0.772
ASA score	I	8 26.7%		7 23.3%		
	II	16 53.3%		21 70.0%	0.254	
	III	6 20.0%		2 6.7%		
Tm size. cm		3.3 ± 1.5	2.7	3.5 ± 1.3	3.5	0.332
Tm laterality	Right	17 56.7%		18 60.0%	0.930	
	Left	13 43.3%		12 40.0%		
Tm location	Upper pole	10 33.3%		9 30.0%		
	Middle pole	8 26.7%		8 26.7%	0.955	
	Inferior pole	12 40.0%		13 43.3%		
	Anterior	18 60.0%		11 36.7%	0.071	
	Posterior	12 40.0%		19 63.3%		

BMI: Body mass index, kg/m^2 / ASA: American Society of Anesthesiologists / Tm: Tumor.

TABLE 2: Comparison of the groups according to surgical method with perioperative parameters.

	LPN		RPN		
	Mean±s.d.	Median	Mean±s.d.	Median	p
Perioperative blood loss, cc	246.8 ± 72.3	230.0	206.0 ± 94.4	200.0	**0.005**
Operation time, min	230.3 ± 22.2	240.0	194.5 ± 44.7	195.0	**0.001**
Warm ischemia time, min	19.2 ± 3.8	19.0	16.2 ± 3.9	15.0	**0.006**
Collecting system entry					
Yes	7 23.3%		3 10.0%		0.166
No	23 76.7%		27 90.0%		

COMPARISON ACCORDING TO RENAL NEPHROMETRY SCORE

In sixty patients, comprising of 30 LPN and 30 RPN cases, 44 patients with RNS <7 (Group A) (73.3%) and 16 patients with RNS ≥7 (Group B) (26.7%) were compared in terms of the perioperative values. The median age was 51.2 ± 13.3 and 51.7 ± 12.1 in Group A and Group B, respectively. The mean BMI was found to be 27.2 ± 3.7 kg/m^2 and 27.1 ± 3.1 kg/m^2. In both groups, there were no statistically significant differences in age, sex, BMI and ASA scores of the patients (p>0.05). In Group A and Group B, tumor size (cm) was 2.9 ± 1.0 and 4.9 ± 1.2, respectively. Tumor size was found to be significantly lower in Group A (p<0.05). No statistically significant difference was found between both groups in terms of the renal side with the tumor location, the kidney pole with tumor location and the anterior/posterior location in the kidney (p>0.05) (Table 3).

The mean perioperative EBL (ml) was found to be 200.1 ± 45.2 in Group A and 298.8 ± 124.6 in Group B, respectively. OT (min) was found to be 204.9 ± 41.8 in Group A and 233.1 ± 21.7 in Group B, respectively. WIT was found to be 15.8 ± 2.8 min in Group A and 21.8 ± 3.5 min in Group B, respectively. Perioperative EBL, OT, and WIT were found to be significantly lower in Group A (p<0.05). The collecting system entry was recognized in 4 patients

TABLE 3: Preoperative characteristics of patients and tumors according to surgical method.

		Group A		Group B		
		Mean±s.d./n-%	Median	Mean±s.d./n-%	Median	p
Age, years		51.2 ± 13.3	51.0	51.7 ± 12.1	49.0	0.933
Sex	Male	28 63.6%		10 62.5%		0.936
	Female	16 36.4%		6 37.5%		
BMI		27.2 ± 3.7	27.0	27.1 ± 3.1	26.5	0.847
ASA score	I	13 29.5%		2 12.5%		
	II	24 54.5%		13 81.3%		0.170
	III	7 15.9%		1 6.3%		
Tm size, cm		2.9 ± 1.0	2.7	4.9 ± 1.2	4.6	**0.000**
Tm laterality	Right	28 63.6%		7 43.8%		0.167
	Left	16 36.4%		9 56.3%		
Tm location	Upper pole	15 34.1%		4 25.0%		
	Middle pole	12 27.3%		4 25.0%		0.707
	Inferior pole	17 38.6%		8 50.0%		
	Anterior	23 52.3%		6 37.5%		0.311
	Posterior	21 47.7%		10 62.5%		

BMI: Body mass index, kg/m^2 / ASA: American Society of Anesthesiologists / Tm: Tumor.

TABLE 4: Comparison of the groups according to RENAL nephrometry score with perioperative parameters.

	Group A		Group B		
	Mean±s.d.	Median	Mean±s.d.	Median	p
Perioperative blood loss, cc	200.1 ± 45.2	210.0	298.8 ± 124.6	250.0	**0.002**
Operation time, min	204.9 ± 41.8	207.5	233.1 ± 21.7	237.5	**0.014**
Warm ischemia time, min	15.8 ± 2.8	16.0	21.8 ± 3.5	22.5	**0.000**
Collecting system entry					
Yes	4 9.1%		6 37.5%		**0.009**
No	40 90.9%		10 62.5%		

in Group A (9.1%) and in 6 patients in Group B (37.5%). When both groups were compared, the rates of collecting system entry were found to be statistically significantly higher in Group B ($p<0.05$) (Table 4).

DISCUSSION

According to the findings of our study, RPN is an important alternative to LPN. Similar to our study, Pierorazio et al. compared in their study the first RPN and LPN cases performed by a single surgeon. In their study which compared 48 RPN and 102 LPN cases, EBL, OT, and WIT were reported to be significantly lower in the RPN group.[16] In a meta-analysis published by Choi et al., the results of RPN and LPN were compared. When the results of 23 centers involving 2240 patients were evaluated, it was reported that WIT was statistically significantly low in the RPN group whereas OT and EBL were not different between the groups.[4] In another meta-analysis with a relatively larger patient population, which included 25 recently published studies and compared 2681 RPN and 2239 LPN cases, it was reported that there was no significant difference between the two methods in terms of perioperative EBL and OT, while WIT was significantly lower in RPN.[17]

As mentioned above, the results described in studies comparing LPN and RPN surgical methods according to perioperative results are controversial. Which method is superior is still a debatable issue in the publications, especially in terms of EBL and OT from among the perioperative values. In a recent prospective study in which operations were performed by two surgeons who completed their learning curves in LPN and RPN, it was demonstrated that WIT was longer in the LPN group, there was no statistically significant difference in OT, and EBL was higher in the RPN group. However, it was demonstrated that there were no differences between both groups in terms of short-term functional and oncologic outcomes. And also they have stated that the weaker perioperative results in LPN in the literature is linked to the incomplete learning curve.[18] In our report, the first LPN and RPN cases of a surgeon who exceeded the learning curve in laparoscopy and robotic surgery were included. Therefore, we think that our results will contribute to the literature.

There are several factors that influence the change of renal function after PN. Preoperative GFR, age, comorbidity and tumor size are both patient and tumor factors and they cannot be modified. WIT and decreasing renal volume during tumor resection are modifiable factors.[11] The importance of WIT is well known. Becker et al. reported that WIT should be less than 20 minutes during nephron-sparing surgeries.[19] Thompson et al. demonstrated that even 1 minute of WIT in PN was effective on postoperative renal functions and 4 times more stage 4 chronic renal failure developed in patients with WIT over 25 minutes.[20] In our study, WIT, EBL and OT were statistically lower in the RPN group. However, these differences between groups may be questioned in terms of clinical significance. Because the difference of WIT was only 3 minutes and both were under the 20-minute range (16-19 minutes). There is also a similar situation for EBL. Although the statistics can show a significance, a difference of 40 cc blood loss (246 vs. 206) can be accepted meaningless clinically.

RPN and LPN surgical techniques are similar. In this study, WIT, EBL and OT in the RPN group were lower than the LPN Group and we think that this results from unique features of the robotic system such as motion capability of instruments and improved visualisation, and thus easier tumor excision and parenchyma reconstruction. As another reason, although the surgeon in our study performed LPN operations after passing the learning curve in laparoscopy, we think that he passed the learning curve in robotic surgery faster since he began robotic surgery after long-term experience in laparoscopy and thus he was faster in robotic surgery. This is also one of the limitations of our study. We think that the use of V-LocTM as a suture for renorrhaphy was effective in keeping the WIT time below 20 minutes for both surgical methods. Thanks to its barbed structure, it allows the suture to hold the tissue more firmly and as a result, early unclamping is more possible than other non-barbed sutures. In a recent randomized controlled trial, cases which V-LocTM was used and not used for renorrhaphy in LPNs were compared. It was demonstrated that WIT and renorrhaphy time were statistically significantly shorter in the group with VLocTM than in the group without VLocTM and there was no significant difference in OT and perioperative EBL.[21]

The anatomical features of the tumor play an important role in determining the optimal treatment for renal tumors. RNS was developed to determine the objective anatomical features of renal tumors. As a result of advanced technologies such as robotic surgery, it is now possible to perform PN even on more complex renal tumors.[9,22-24] In our study, no statistically significant difference was observed in RNS risk groups between RPN and LPN groups. Also, the patient groups in the same risk group with RNS were not compared by the surgical method since the number of patients in these risk groups was not sufficient for statistical analysis. This is another limitation of our study. Instead, all patients in the study were compared after grouping based on the RNS score of <7 and ≥7.

In the literature, studies involving cases that underwent PN and comparing the operative values in risk groups relative to RNS are available. In a recent study reported by Schiavina et al., 277 RPN cases were included in the study. Patients were divided into low, medium and high-risk groups based on RNS, and the operative results and postoperative complications were compared. As a result of the study, longer WIT, higher collecting system entry, longer OT and more postoperative complications were observed in complex tumors. It was reported that perioperative EBL was not associated with the scoring system.[25] A recent meta-analysis of 41 studies where host factors affecting the RPN outcomes were investigated and a total of 10,506 patients were included, it was reported that factors such as tumor size of >4 cm or complexity relative to RNS were associated with increased OT and WIT and EBL.[26] Similarly, in our study, perioperative EBL, OT, and WIT were found to be significantly higher in complex tumors compared to RNS. Also, the collecting system entry was found to be 9.1% in the RNS group with a score of <7 and significantly higher in the group with a score of ≥7 (37.5%). Eventually, our study supports that it is important to know the RNS score for predicting perioperative outcomes in partial nephrectomies.

Our study has also some general limitations, except those mentioned above. The first limitation is the retrospective and non-randomized design of our study. Another limitation of our study is that it is single-centered and performed by a single surgeon, although this led to a more homogenous result. In terms of its strength, the small number of patients is also another limitation to our study.

CONCLUSION

RPN is an effective and feasible method with lower perioperative EBL and shorter OT and WIT compared to LPN and is an important alternative to LPN. However, when we look at these results by a clinicians' point of view, the results of the two surgical methods are comparable. Therefore, in partial nephrectomies, it would be more appropriate for the surgeon to choose the surgical method with sufficient experience. Also, RNS is a valuable tool that enables us to predict perioperative results in partial nephrectomies.

Informing

Due to the presence of the name of the journal editor's among the authors, the assessment process of the study was conducted by the guest editor.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and/or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Abdullah Hızır Yavuzsan, İsmail Evren, Abdulmuttalip Şimşek, Ali İhsan Taşçı;* ***Design:*** *Abdullah Hızır Yavuzsan, Taner Kargı, İsmail Yiğitbaşı, Volkan Tuğcu;* ***Control/Supervision:*** *Abdulmuttalip Şimşek, Ali İhsan Taşçı, Volkan Tuğcu;* ***Data Collection and/or Processing:*** *Abdullah Hızır Yavuzsan, İsmail Yiğitbaşı, Taner Kargı;* ***Analysis and/or Interpretation:*** *Abdulmuttalip Şimşek, Selçuk Şahin, Abdullah Hızır Yavuzsan, Taner Kargı;* ***Literature Review:*** *Abdullah Hızır Yavuzsan, İsmail Evren, İsmail Yiğitbaşı, Taner Kargı;* ***Writing the Article:*** *Abdullah Hızır Yavuzsan, Ali İhsan Taşçı, Volkan Tuğcu, İsmail Evren;* ***Critical Review:*** *Ali İhsan Taşçı, Volkan Tuğcu.*

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