Review Article

Laparoscopic radical and partial nephrectomy: The clinical efficacy and acceptance of the techniques

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Abstract

The laparoscopic approach has been established as the surgical procedure of choice for radical nephrectomy during the recent years. The advantages of the laparoscopic radical nephrectomy in comparison to the open approach are well-documented. The oncological results of the laparoscopic approach are similar to the open procedure while the post-operative morbidity is lower. Laparoscopic partial nephrectomy seems to gain ground to its open counterpart, as the accumulation of experience in the technique grows. In this review, a PubMed search in the latest literature on radical and partial laparoscopic nephrectomy took place and the outcome of the search is presented. Several issues about the surgical techniques and clinical efficacy are discussed. In addition, the preliminary experience in laparoscopic nephrectomy of one of the authoring institutions is also presented.

Key Words: Laparoscopic partial nephrectomy, laparoscopic radical nephrectomy, renal cell carcinoma, renal tumors, Saudi Arabia

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INTRODUCTION

Until the introduction of laparoscopic surgery for renal tumors in 1990s, open surgery was the only option for the management of renal tumors. Now-a-days, laparoscopic radical nephrectomy (LRN) is the treatment of choice for $T_2N_0M_0$ tumors.[1] Open partial nephrectomy is still the gold standard for smaller tumors, but laparoscopic partial nephrectomy (LPN) may replace it in the near future.[2]

In this review, the clinical efficacy and outcome as well as technical issues of laparoscopic radical and partial nephrectomy are discussed. The preliminary experience in laparoscopic nephrectomy of the authoring institution in Saudi Arabia is presented.

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LRN

Background

According to the EAU Guidelines, LRN is the standard of care for T_2 stage tumors.[1] LRN and open radical nephrectomy (ORN) have similar oncological outcomes for these renal tumors.[3,4] Despite the large experience with LRN, it remains questionable whether this technique is indicated for renal tumors of higher than T3bN0M0.[5] Nevertheless, the technique was proven to be feasible in the case of the aforementioned large tumors.[6,7] The European Association of Urology recently proposed nephron-sparing surgery (NSS) for T1a and T1b renal tumors, whenever technically feasible. Patients with the above tumors in a solitary kidney have an absolute indication for the OPN.[1] As the laparoscopic experience accumulates world-wide, more indications are applied to the technique. Several technical issues concerning LRN and different approaches follow.

Technical issues

Transperitoneal or retroperitoneal approach?

There are two approaches in LRN: the retroperitoneal and the transperitoneal approach. The transperitoneal approach is considered the access of choice, while the retroperitoneal approach is indicated in patients with intraperitoneal adhesions due to previous abdominal surgery. The retroperitoneal access could also be considered as an alternative to transperitoneal access, as it may be associated with shorter operative time in comparison to its transperitoneal counterpart.[8] The comparison of the retroperitoneal laparoscopic to the open approach showed a complication rate of 17% and a conversion rate of 7% for the laparoscopic cases in a group of tumors of a diameter up to 9 cm.[9] No difference was observed in complication rates and in technical difficulties for the laparoscopic surgeon in a prospective randomized trial comparing the transperitoneal to the retroperitoneal.[8] The oncological outcome has no difference between the two approaches, while advantages regarding the hilar control and the total operative time were documented in the retroperitoneal nephrectomy.[10] Nevertheless, the limited surgical field in the retroperitoneal approach poses a major drawback in this technique. Laparoscopic surgeons are more familiar with the transperitoneal access, as the latter is also used for other procedures such as prostatectomy.[11] In a recent systematic review and meta-analysis, it has been pointed out that the retroperitoneal approach may be faster and equally safe compared with the transperitoneal access.[10] The learning curve of retroperitoneal nephrectomy has been calculated to be 8 cases in a porcine model.[12] The retroperitoneal approach may be more widely acceptable in the future due to the aforementioned advantages.

Hand-assisted approach

It is debatable whether the LRN should be performed by pure laparoscopic or by hand-assisted laparoscopic approach.[13-16] The hand-assisted radical nephrectomy (HALRN) requires the use of trocars plus a large hand port, while LRN needs only trocars. It has been considered by some investigators that HALRN is the first step of the un-experienced laparoscopic surgeon towards the pure laparoscopic approach.[17] In a meta-analysis that compared the hand-assisted approach to the pure laparoscopic approach, revealed that conversion rates and blood loss were lower in the hand-assisted approach. The cases included both radical and donor nephrectomies. Despite the lower blood loss of the hand-assisted technique, the transfusion rates were similar between both groups and eventually the difference in blood loss was considered to be of no clinical importance. In the hand-assisted technique, the better tactile sensation of the tissues resulted in the lower conversion rates.[18] In a prospective randomized study, the LRN and the HALRN were compared having no difference in the majority of the perioperative parameters. The only difference was the longer convalescence and the longer period required to return to work for the hand-assisted group.[19] Consequently, the experience of the laparoscopic surgeon and the characteristics of each patient are the most important factors in the selection of the appropriate technique.

Clinical efficacy of LRN

In a retrospective non-randomized study, transperitoneal or retroperitoneal LRN and ORN were performed for T2 tumors of approximately 10 cm in diameter. The LRN group had better short-term post-operative results compared to the ORN group and the complication rate was 12% and 15%, respectively. While the mean follow-up was 57 months for ORN and 51 months for LRN, no significant differences were observed in cancer-specific and survival rates. Nonetheless, the laparoscopic surgeon should be experienced in order to perform the operation in such large tumors, as the tumor size was technically challenging.[20]

In a recent prospective study, LRN was compared with ORN regarding T1 or T2 tumors with a maximal diameter of 15 cm. Mean tumor diameter was 5.8 cm for the LRN group and 6.2 cm for the ORN group. LRN was better regarding blood loss during the operation and hospital stay. For a mean follow-up period of 60 months for LRN and 72 months of ORN, cancer-specific survival was 90 and 92%, respectively. Regarding the overall survival, it was 81% for LRN and 79% for ORN. The main advantages of LRN are the better post-operative results, while there was no difference in the oncological outcome between the two procedures.[21]

In a randomized controlled trial comparing LRN and ORN of 45 patients with renal tumors up to 8 cm, the operative time had no significant difference in comparison to ORN and the hospital stay was reported to be 1 day shorter for the LRN. Lower post-operative pain and shorter convalescence period was observed in the LRN group, while the pain was similar between both groups at 3 months post-operatively.[22]

In a comparative study including 336 patients with 7 years follow-up, cancer-specific survival was 92.5% and 91.2% for LRN and ORN, respectively.[9] The selection of the procedure did not influence the oncological outcome, but tumor grade was a significant prognostic factor. In another study of a mean follow-up of 11.2 years, the overall survival rate was 35%, the cancer-specific survival rate was 78% and the recurrence-free survival rate was 77% at 12 years. The oncological outcome of LRN was excellent and did not differ to the oncological outcome of ORN.[23]

LPN

Background

Partial nephrectomy is recommended by EAU Guidelines for the management of T1a and T1b renal cell tumors.[1] Absolute

indications are cases of anatomic or functional solitary kidney and bilateral renal cell carcinoma (RCC). Decreased function of the contralateral kidney, systemic disease that could influence renal function in the future, hereditary types of RCC associated with risk of tumor development in the contralateral kidney, diabetes, renovascular disease and hypertension are relative indications. Its technical difficulties have made LPN to be an alternative surgical approach to the gold standard open partial nephrectomy (OPN). OPN is the gold standard, but recently it has been challenged by LPN, which in the hands of experts appear to have similar oncological results.[24]

LPN is a challenging procedure. The surgeon that performs it should have the adequate experience and delicate skills.[24] A surgical margin of a few millimeters is required for optimum oncological results.[25] The size of the tumor may represent a challenge for the adequate resection. Thus, T1b tumors are recommended to be under intensive surveillance. Relative contraindications for the laparoscopic approach are: Complex mid-pole intrarenal/hilar tumor in a patient with imperative indication for NSS or previous open surgery on the same side.[11]

Predictive scoring systems for NSS

During the development of the NSS, two predictive scores have been introduced in an attempt to predict complications and surgery related outcome of partial nephrectomy.[26,27] These scores have been evaluated in LPN. Both scores use radiological and anatomical features such as tumor size and location, morphology characteristics (exophytic or endophytic, involvement of the pelvicalyceal system etc.) and classify the tumors according to their complexity, which is considered to be correlated to perioperative complications. Moreover, these systems allow a consensus in the evaluation of tumors among surgeons.[28] The evaluation of these scores showed that there is not any significant difference among the scoring systems and tumor stage or perioperative complications.[28,29] Pre-operative aspects and dimensions used for an anatomical score ≥ 10 and RENAL score ≥9 are factors demonstrating a high risk for perioperative complications.[30] An increasing RENAL score is associated with histological features of tumor aggressiveness and a greater proportion of major complications.[31] Correlation between the scoring systems and changes in estimated glomerular filtration rate, creatinine levels and warm ischemia time (WIT) has been reported.[32-34] In fact, tumors with higher complexity are associated with higher percent change in creatinine levels in comparison the low complexity tumors.[33] The reproducibility of the both scoring systems has been shown to be high.[28]

Technical issues

Transperitoneal versus retroperitoneal LPN

For lesions located anteriorly or laterally, the transperitoneal approach is used. The retroperitoneal approach has been associated with better outcomes for posterior tumors.[35] Transperitoneal LPN was used in larger tumors and was linked with more pelvicaliceal repairs and longer WIT, operative time and hospital stay compared to retroperitoneal LPN. No significant difference was observed between the two approaches in perioperative complications, post-operative pain, post-operative renal function and estimated blood loss.[35,36]

Hemostasis

Hilar clamping is the most commonly used method to achieve a bloodless surgical field. During tumor excision, it is also very difficult to minimize the blood loss. One of the methods proposed is the percutaneous radiofrequency (RF) coagulation. RF results in a spherical coagulation area 1 cm around the lesion. Cold scissors or ultrasound shears are used to resect the tumor and reduce the blood loss. The major complications of the RF coagulation were the collateral damage of renal vasculature and collecting system, delayed urinary fistula and difficulty to distinguish the tumor margin.[37,38] Monopolar RF device made LPN possible without clamping the renal vessels. This device provides simultaneous dissection, hemostasis and coagulation. Mean tumor size and mean estimated blood loss was 3.9 cm and 352 ml, respectively.[38]

The hemostatic sealant Floseal (Baxter Healthcare, USA) is another product that provides hemostasis of the surgical field of LPN. It is composed of a cross-linked gelatin granules and topical thrombin glue. When Floseal was used, significant overall complications and hemorrhages were less frequent.[39] Floseal is placed at the site of the sutured renal incision at the end of the procedure. Several other bioglues have been used, such as fibrin glue (Tisseel; Baxter), bovine serum albumin-based adhesive (BioGlue; CryoLife), cyanoacrylate glue (Glubran; General Enterprise Marketing) and other hemostatic agents. All these agents have been evaluated in a multi-institutional study with 1347 cases of LPN.[40] The benefit of these agents is not well proven and should be used to control minor bleeding in conjunction with other measures such as parenchymal suturing over a bolster.

Hilar control and warm ischemia

Post-operative renal function is very important after a partial nephrectomy and is determined primarily by three factors: pre-operative renal function, volume of renal mass preserved and surgical renal ischemia. Minimization of surgical ischemia is achieved by early unclamping and unclamped (zero ischemia) techniques. A variety of methods have tried to achieve hilar control and shorter WIT. The most frequently used method is the clamping of renal vessels. Clamping only the renal artery or intermittent clamping has been used also.

WIT of no more than 30 min seems to be really important for the post-operative renal function.[25] Nevertheless, there is no adequate evidence to decide which method is the most appropriate. WIT of more than 60 min has been reported and is not proven to be related to permanent renal function damage, while an average WIT of 22.5 min (range 10-44 min) was not associated with any renal function and glomerular filtration deterioration.[41]

Desai *et al.* studied 179 patients who underwent LPN. A solitary kidney has been reported in 19 patients, where the average WIT was 29 min and an average of 29% of the kidney was excised. Renal scintigraphy was used to measure the renal function in patients with both kidneys and it has been shown that there has been a reduction in 29% in the operated kidney. WIT of 30 min has been associated with no important deterioration in renal function. Consequently, it is recommended to keep the WIT less than 30 min.[42]

Another technique to reduce the ischemia time is the early unclamping of the renal vessels. The unclamping takes place right after the first parenchymal suturing and the remaining sutures are done without vessel clamping. The early unclamping has significantly reduced ischemia time to half. Similar results were confirmed also by other studies.[43]

Another method to reduce the effects of warm ischemia is the placement of thrombin gel slurry to the renal lesion after tumors excision. The gel is pressed on the injured surface of the kidney by a sponge stick for 1-2 min and then the renal vessels are unclamped. The results were 13 min of WIT and 200 ml of estimated blood loss on average.[44]

Zero ischemia has been also tried lately with good results. LPN without hilar clamping is feasible, safe and associated with less renal injury as assessed by post-operative glomerular filtration rate in select patients.[45,46] With experience, it can be applied to complex renal lesions.

Renal hypothermia

A method to reduce the complications of renal ischemia is the intracorporeal hypothermia to the surface of the renal parenchyma. The renal vessels are clamped and an endoscopic bag is filled with 600-750 ml of ice. The renal temperature ranged between 5°C and 19°C.[47] Another method to achieve renal hypothermia consists of perfusing the renal parenchyma with a 4°C solution by an angiocatheter placed peripherally of the clamp occlusion. A mean temperature of 25°C was shown in the renal parenchyma. Nevertheless, this is not satisfactory, as the optimal hypothermia temperature is below 15°C.[48] Another way to cause renal hypothermia is to perfuse the kidney with cold saline through a ureteral sheath. Again, the temperatures that were demonstrated were not adequate to prevent serious renal damage (24°C for the renal cortex and 21°C for the renal medulla).[49] The clinical use of renal hypothermia to reduce the ischemia related renal damage remains to be proven by further studies. Further technical details have to be improved in order to see the widespread distribution of these techniques.

Pelvicaliceal repair

The opening of the pelvicaliceal system of the kidney is associated with longer WIT and longer hospitalization. Nevertheless, urinary leakage is not a common complication when repair of the pelvicalyceal system is performed. While ureteral stents do not alter the natural history of the urinary leakage, the use of these stents is indicated in the following cases: (1) To specify the site of the pelvicaliceal entry (there may be more than one entries); (2) to test the tightness of the pelvicaliceal repair by retrograde injection.[50]

Clinical efficacy of LPN

LPN and open partial nephrectomy have been compared in order to find the advantages of each approach. LPN is linked with less blood loss and shorter hospital stay.[51] In addition, operative time has been controversially reported to be either longer or shorter for the open approach. Nevertheless, the cases treated by LPN presented tumors of smaller size and the advantages in operative time should probably be attributed to this.[52] The two approaches did not show differences in the oncological outcome which was similar after long-term follow-up.[53,54] The learning curve played a significant role in the beginning of the laparoscopic experience and higher complication rates were obserevd. After the accumulated experience, the complication rates were similar to the two approaches.[51] Currently, the outcome of LPN concerning WIT, post-operative complications and post-operative renal function seems to be improving and matching the results of OPN.

The initial experience in laparoscopic nephrectomy of the Saudi Arabian author in this review.

Twenty-five patients underwent transperitoneal laparoscopic nephrectomy in a year (April 2011-April 2012). The nephrectomy was performed by a urologist who was trained in a program dedicated to endoscopy and laparoscopy and the current series represents his first experience in his institution. The mean age of the treated patients was 43 years old (range 7-59). 16 (64%) of them were men and 9 (36%) were women. The indications for nephrectomy included patients with non-functioning kidneys in 60% of the cases, while a renal mass was diagnosed in 24% of the cases. The demographics of the patients are summarized in Table 1.

All data for the above series were prospectively recorded and the follow-up period was 1 year. The average operation time was 2.5 h (range 2-3 h) and hospitalization time ranged between 3 and 5 days, with an average of 4.5 days. Blood transfusion was performed in 2 patients (8%). The histologic findings along with other perioperative details and rates of post-operative complications are presented in Table 2. Two post-operative complications were encountered: A retroperitoneal hematoma, which was treated conservatively and an incisional hernia, which was treated by a mesh placement (Clavien classification grades II and IIIb respectively[55]). Conversion to open approach was never necessary.

The initial experience showed promising results for the future. Operative time and complication rates are comparable to those presented in literature despite the presence of a portion of the learning curve in the current series. With increasing experience, the results would probably improve and the transition from open surgery to laparoscopy would be possible.

CONCLUSION

LRN has been established as the gold standard for renal tumors with improved outcomes in comparison to ORN. LPN is still under clinical evaluation and the continuous development shows that the technique will eventually be established as a standard method for the management of small renal tumors in the future. Urological research seems to work continuously towards the latter aim by providing new concepts and technical tools to the laparoscopic armamentarium.

Table 1: Demographics of patients and indications for surgery

Mean age, years (range)	43.0 (7-59)
Male, *N* (%)	16 (64.0)
Female, *N* (%)	9 (36.0)
Non-functioning kidney, *N* (%)	15 (60.0)
Renal mass, *N* (%)	6 (24.0)
Other indication, *N* (%)	4 (16.0)

Table 2: Perioperative outcome, histopathology and complications of the current series

Duration in OR, mean hours (range)	2.5 (2-3)
Hospitalization, average days (range)	4.5 (3-5)
Histopathology	
End stage renal disease, *N* (%)	16 (64.0)
Renal cell carcinoma, *N* (%)	4 (16.0)
Oncocytoma, *N* (%)	2 (8.0)
Xanthogranulmoatous pyelonephritis, *N* (%)	1 (8.3)
Positive surgical margins, *N* (%)	0
Blood transfusion, *N* (%)	2 (8.0)
Post-operative complications, *N*, Clavien grade	1, II 1, IIIb

OR: Operative Room. The complications are graded according to Clavien-Dindo[55]

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