Results of laparoscopic resection of kidney tumor in everyday clinical practice

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KEY WORDS

kidney tumor ◗ kidney ◗ laparoscopy ◗ nephrectomy ◗ resection of kidney

ABSTRACT

Introduction. Laparoscopic resection (LR) of kidney tumours is still under evolution. However laparoscopic "centres of excellence" (high volume centres) have published relatively good results of LRs. We would like to show the possibility of applying this technique in everyday clinical practise.

Material and methods. The results of a group of 62 LR performed 2004 – 2008 was compared with 62 open resections (OR) and the first half of 31 LR was compared with the other half.

Results. LR constitutes 9.4% of procedures for kidney tumors and 25.9% of resections at our institution. The results of OR vs. LR were the following: ischemia time (13.2 *vs.* 19.1 min, p <0.01), hospital stay (8.4 *vs.* 7.7 days, p = 0.078), and complications (12.9 *vs.* 27.4%, p = 0.720). Comparison of former LR and latter LR: operation time (124.5 *vs.* 99.5 min p = 0.023), ischemia time (23.1 *vs.* 13.8 min, p <0.01), hospital stay (8.1 *vs.* 5.6 days, p <0.01), and complications (32.3% *vs.* 22.6%, p = 0.384).

Conclusions. LR have a higher ischemia time and complications than OR. Values decrease with the number of operations, however values remain better overall with OR. We recommend LR, nevertheless only in highly selected cases with respect to the dexterity of the individual surgeon. OR remain the gold standard in nephron sparing surgery.

INTRODUCTION

Kidney tumors are an important part of the work of Czech urologists because the incidence of kidney tumors is very high (in 2005, males 34.9 and females 19.3 per 100,000 inhabitants per year), the highest from all over the world. Due to this reason, surgery of kidney tumors is an extremely important topic in everyday urological practice in the Czech Republic and the growing number of incidentally diagnosed small tumors lead to an interest in minimally invasive techniques.

It is has been over 10 years since the introduction of the first more extensive publication about laparoscopic resections (LR) of kidney tumors [1]. The rate of complications was high, but with increasing experience and technical refinements, the complication rate has decreased substantially. The technique of LR is permanently evolving. Laparoscopic "centers of excellence" (high volume centers) have published relatively good results of LR of kidney tumors. We can read about excellent results of LR from many articles in various journals, but most articles have their origin in a limited number of these "centers of excellence" and the same series are published from different points of view only. Former indications for LR were small exophytic renal tumors well accessible to laparoscopic instruments. Centers of excellence are able to resect even more complex tumors – a tumor of the upper pole [2], central [3] and hilar tumors [4, 5], tumors T1b, T2 and worse [6, 7], other unusual cases (previous renal surgery, multiple tumors, adrenal gland involvement, concomitant renal artery disease, obese patients), and even in a solitary kidney [8]. What is typical for this center of excellence? The surgery is performed mostly by a single surgeon [2, 4, 5, 9-11], by two surgeons [3, 12], or even three surgeons [13]. In all these centers, LR is the leading or one of the leading topics of their works and all of these urologists are fans of LR and they are super-specialized for LR. We would like to present the possibility of applying this technique to everyday clinical practice. We have compared our results of LR with results in the "center of excellence" as well as with our results of OR. We have analyzed the possibilities of improving the technique in the course of time. We compared the results at the start of the method (first half of LRs) with a later period with higher opinions.

MATERIAL AND METHODS

A program for the laparoscopic resections (LR) of kidney tumors was established at our institution in September 2004. As of December 2008, 76 patients were indicated for LR. Only a simple kidney cyst was found in 8 cases (a standard laparoscopic ablation of cyst was performed in all cases) and in 1 case a tumor wasn't found. In five patients a rigid fibrotic perirenal fat tissue, due to perinephritic changes, was found and the operations were accomplished through an open approach while the laparoscopic part of the operation was qualified as a diagnostic laparoscopy only. In the remaining 62 patients, LR were carried out. Representation of LR in the portfolio of kidney tumor surgery is shown in table 1.

A group of LR is evaluated in detail and they are compared with a group of 62 open resections (OR), which were provided before starting the program of LR (1/2002 – 8/2004). For the OR group, similar patients were chosen. Solitary kidney and central tumors were excluded. The 62 patients (46 [76.1%] of them were men) in OR have no statistical difference in age or tumor size compared with LR. LR were performed by one surgeon (MH) skilled in laparoscopy and open surgery as well. OR were accomplished by a group of 6 surgeons.

Our technique for LR is as follows: We indicate mainly exophytic tumors easily accessible for laparoscopic instruments. We exclusively use a transperitoneal approach, a retroperitoneoscopic approach was chosen only in one case in a patient with previous abdominal surgery. On the left side, four ports are introduced (5, 2 x 10 and 12 mm); on the right side one 5 mm port for elevation of the liver. The peritoneum and Gerota's fascia are open and the tumor is recognized. Hilar vessels are identified. In this phase, a biphasic CT angiography is very helpful [14]. We don't use pe-

Table 1. Type of surgery in 2004-2008 in patients with the diagnosis of a kidney tumor (D 30.0 and C 64).

Type of surgery	2004		2005		2006		2007		2008		Together	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
Open nephrectomy	24	26.7	46	35.4	38	29.7	42	26.6	36	23.4	186	28.2
Laparoscopic nephrectomy	35	38.9	40	30.8	47	36.7	57	36.1	56	36.4	235	35.6
Open resection	27	30.0	29	22.3	26	20.3	51	32.3	44	28.6	177	26.8
Laparoscopic resection	4	4.4	15	11.5	17	13.3	8	5.1	18	11.7	62	9.4
Total	90		130		128		158		154		660	100

Table 2. Comparison of results of laparoscopic (LR, N1 = 62) vs. open (OR, N2 = 62) resection.

	Age (years)		Tumor size (mm)		Operation time (min)		Clamping time (min)		Hospitalization (days)		Follow-up (months)		Blood loss (ml)	
	LR	OR	LR	OR	LR	OR	LR	OR	LR	OR	LR	OR	LR	OR
Mean	61.6	59.2	25.6	32.1	111.8	115.5	19.1	13.2	7.7	8.4	24.8	59.7	199.5	143.6
Standard deviation	12.5	14.5	8.2	12	29.5	29.6	9.0	4	2.2	2.1	14.9	6.1	312.3	81.2
Minimum	25.6	21.7	11	20	50	65	0	0	4	4	2.7	52.5	0	20
Maximum	83	77.9	50	62	180	240	40	20	19	17	52.4	83.2	1500	500
Wilcoxon test (p)	0.371186		0.048791		0.947970		0.000363		0.07795		NA		0.660574	

Table 3. Clamping of renal vessels in LR group.

Type of clamping			Together		1st half		2nd half	
			No	%	No	%	No	%
Artery and vein			28	45.2	13	41.9	15	48.4
	En bloc	intra-abdominal clamp	15	24.2	11	35.5	4	12.9
		extra-abdominal clamp	7	11.3	1	3.2	6	19.4
	Artery and vein separately		6	9.7	1	3.2	5	16.1
Only artery			28	45.2	18	58.1	10	32.3
	Main artery		19	30.6	12	38.7	7	22.6
	Only branch		9	14.5	6	19.4	3	9.7
Without clamping			6	9.7	0	0	6	19.4
Together			62	100	31	100	31	100

rioperative ultrasonography. Renal hilar vessels are clamped. We prefer selective clamping of the renal artery only with an intracorporeal endo-clamp. For a deeper tumor, we clamp the renal vein as well. In a more complex hilum, we clamp it *en bloc* with an intracorporeal clamp or a big extracorporeal clamp introduced through an extra port (immediately through the abdominal wall or through a flexible port). The tumor is excised with cold scissors. Small vessels at the bottom of the resection eventually collecting system are closed with a running polyglactin absorbable suture and anchored with an intracorporeal knot or with absorbable PDS clips (it is faster). We don't take a frozen section from the inferior pole. The margins of the kidney are then sutured together with a running polyglactin suture anchored with PDS or Hem-o-lok® Weck clips. Only in elective cases (3 times), a suture was performed over a Surgicel® bolster. Eight times the thrombin sealant, FloSeal® was used. Clamping of hilar vessels is withdrawn. Coverings of the kidney (pararenal fat tissue, Gerota's fascia, and peritoneum) are tailored.

In 6 cases from the latter group of LR, resection without clamping was performed. The tumor is cut from the normal kidney tissue with an activated bipolar curved dissector. In three cases, tumors were very small (12, 11, and 13 mm in diameter), in two cases, tumors (23 and 32 mm) were extremely exophytic (Fig. 1) and in one case, the exophytic angiomyolipoma was 5 cm in diameter.

The results were processed by a statistical program: STATISTICA StatSoft CR. Statistical significance was defined as a value of less than 0.01 (1%).

RESULTS

In 2004 to 2008, 660 surgical procedures for kidney tumors were performed (Table 1). Nephron sparing surgery was accomplished in 36.2% (239). In the resection group, a laparoscopic approach was chosen in 25.9% (62). Tumors were on the right side in 30 cases and on the left side in 32. There were 35 men and 27 women. See table 2 for results. In three cases (4.8 %) LR was combined with ipsilateral

Table 4. Complications of OR and LR (together and in 1st and 2nd half).

Type of complication	OR together		LR together		1st half of LR		2nd half of LR	
	No	%	No	%	No	%	No	%
Hematoma	3	4.8%	4	6.5%	3	9.7%	1	3.2%
Incision of tumor	3	4.8%	5	8.1%	4	12.9%	1	3.2%
Positive margins	1	1.6%	3	4.8%	1	3.2%	2	6.5%
Conversion	0	0.0%	3	4.8%	1	3.2%	2	6.5%
Bilateral orchiepididymitis	0	0.0%	1	1.6%	1	3.2%	0	0.0%
Trauma of segmental artery	0	0.0%	1	1.6%	0	0.0%	1	3.2%
Hypertension	1	1.6%	0	0.0%	0	0.0%	0	0.0%
Together	8	12.9%	17	27.4%	10	32.3%	7	22.6%
Number of patients	62	100.0%	62	100.0%	31	100.0%	31	100.0%

Note: p value (Fisher's exact test) OR *vs.* LR is 0.072 and LRs1 *vs.* LRs2 0.384.

Table 5. Comparison of former (LR1) and later (LR2) halves of laparoscopic resection (LR).

	Age (years)		Tumor size (mm)		Operation time (min)		Clamping time (min)		Hospitalization (days)		Follow-up (months)		Blood loss (ml)	
	LR 1	LR 2	LR 1	LR 2	LR 1	LR 2	LR 1	LR 2	LR 1	LR 2	LR 1	LR 2	LR 1	LR 2
Mean	62.4	60.9	26.2	25.0	124.5	99.5	23.1	13.8	8.1	5.6	37.8	12.3	215.7	183.9
Standard deviation	14.3	10.7	6.6	9.6	24.4	29.1	6.9	9.5	3.7	1.5	7.5	7.0	276.8	348.3
Minimum	25.6	41.6	14	11	70	50	9	0	4	3	27.1	2.7	10	0
Maximum	83.0	79.8	40	50	180	180	40	30	19	8	52.4	25.7	1300	1500
Wilcoxon test (p)	0.465447		0.197093		0.023426		0.00566		0.001847		NA		0.698179	

adrenalectomy for adenoma. In these three cases the mean time of the operation was 127 min (150, 115 and 115), mean blood loss 60 ml (100, 0 and 80), and no complications were reported.

We haven't found any statistically significant difference in patients' age, tumor size, and general time of operation. The time of warm ischemia (clamping) was statistically significantly longer in the LR group (see table 2). The type of clamping of renal vessels in the LR group is shown in table 3.

Complications of the LR group are shown in detail in table 4. Comparison of complications in LR and OR groups is depicted in table 5.

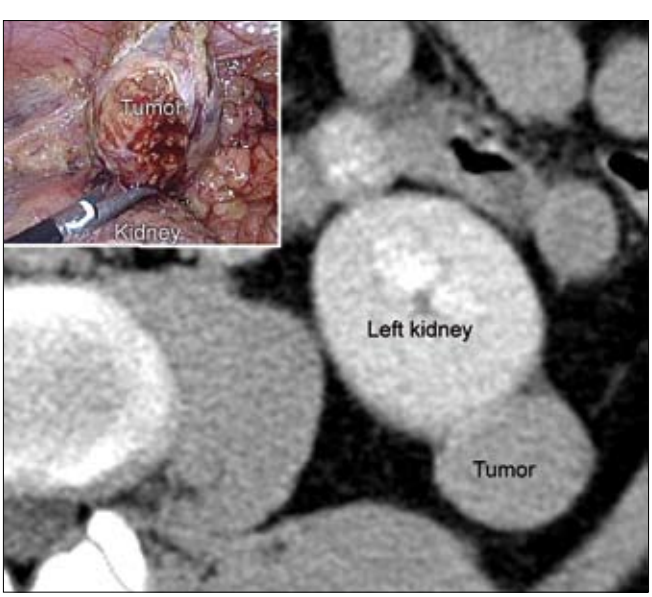


Fig. 1. CT shows an extremely exophytic tumor 32 mm in diameter on the lower pole of the left kidney (man, 50-year-old). In the left corner, perioperative figure shows laparoscopic electrodissection of tumor with bipolar dissector.

Complications were more frequent in the LR group (27.4%) than in the OR group (12.9%). Perioperative blood loss in the LR group was higher than 450 ml only three times (1200, 1300 and 1500 ml) and all cases were treated without transfusion. There were a significant postoperative hematomas in four cases. In all four

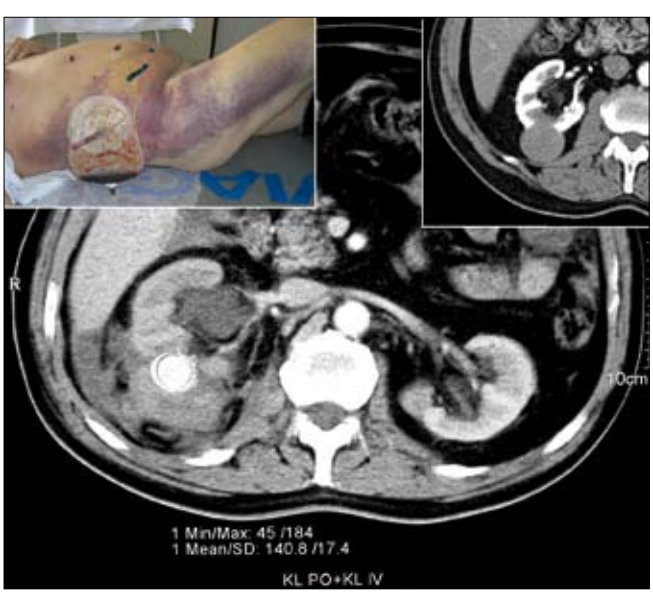


Fig. 2. Man, 74-year-old, tumor of the right kidney 40 mm on CT (see the right upper corner). He underwent laparoscopic surface (not deep) resection with suture of the bed of the resection. Adaptation of edges was impossible due to the much too large area of resection, FloSeal® with Surgicel® were applied. Figure in the left upper corner shows hematoma of the abdominal wall on the 6th postoperative day. Patient was discharged from the hospital on the 12th postoperative day. He was admitted for collapse on the 15th postoperative day. On CT (main figure – contrast fluid IV was applied), fresh bleeding from the bed of resection is visible. Surgeon on-call decided for operative revision followed by nephrectomy.

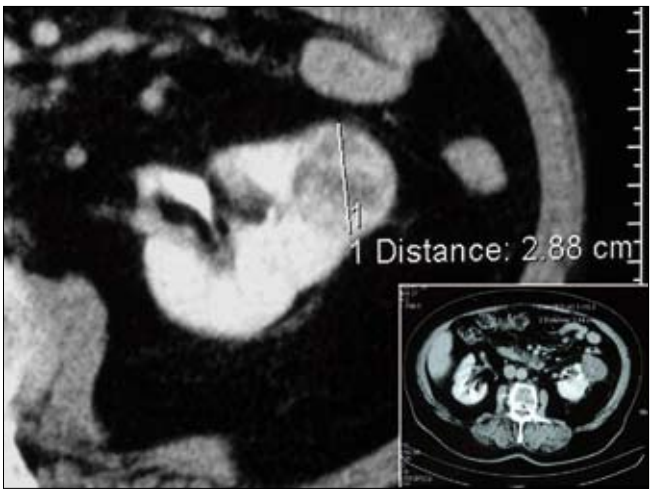


Fig. 3. Woman, 68-year-old, CT (main figure) shows tumor of the left kidney 29 mm. She underwent laparoscopic resection, histology confirmed clear renal cell carcinoma grade 1 with positive margin. CT five months later (the right lower corner) shows unclear resistance in the site of former tumor. Open re-resection was indicated. Hematoma was found and in the surrounding resected kidney tissue, vital tumor of the same entity was found by pathologist.

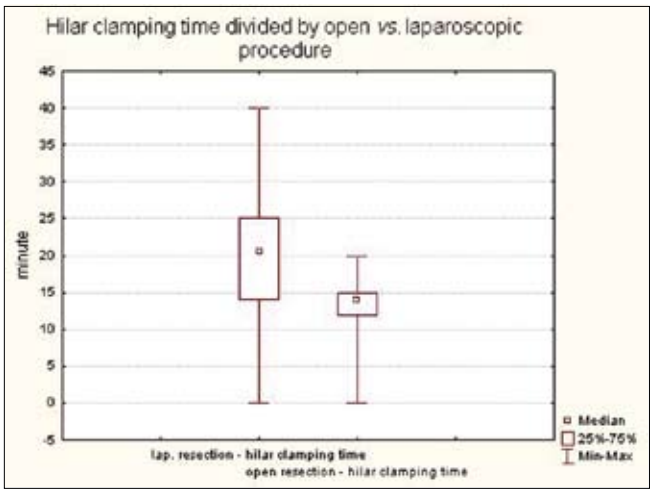
cases, transfusion was applied (3 x 1 unit, 1 x 4 units). Two cases were treated conservatively. In one case, on the 7th postoperative day, super selective embolization of a branch of a segmental artery was performed. In the last case, open correction was indicated on the 15th postoperative day, calling for a nephrectomy (Fig. 2).

There were positive margins in three cases from the LR group. In one case, the histology was oncocytoma and clear renal cell carcinoma (CRCC) in another; the latter patient is carefully being followed-up. In the last case, an open re-resection was performed 6 months later. For details see Fig. 3. One patient in the OR group had a residual tumor or a recurrence of CRCC, we performed an open nephrectomy 6.3 months later but the patient died 13.4 months afterwards from metastasis. In the next five cases of LR, the tumor was cut at the time of the resection. The tumors were then cut in a new plane, which is technically more difficult in LR than in OR.

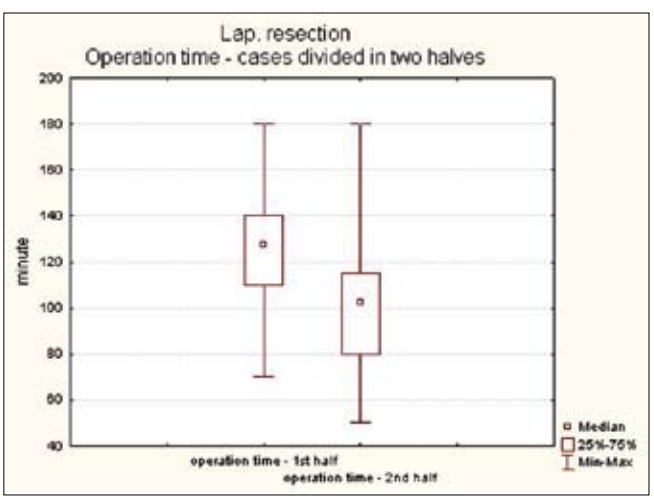
To show whether the results can be improved with increasing experience using our method, we have divided 62 cases of LR into two groups, each consisting of 31 cases. These first (to 31.8.2006) and second (from 1.9.2006) halves were compared (See table 5, rate of complications table 4).

The warm ischemia of the kidney (clamping time), hospital stay, and operation time were all statistically significantly longer in the first group (see graph 2 and 3). As mentioned earlier, we performed the tumor's enucleation without clamping the hilum in 6 cases (19.3%, 6/31) in the latter half of the LR group.

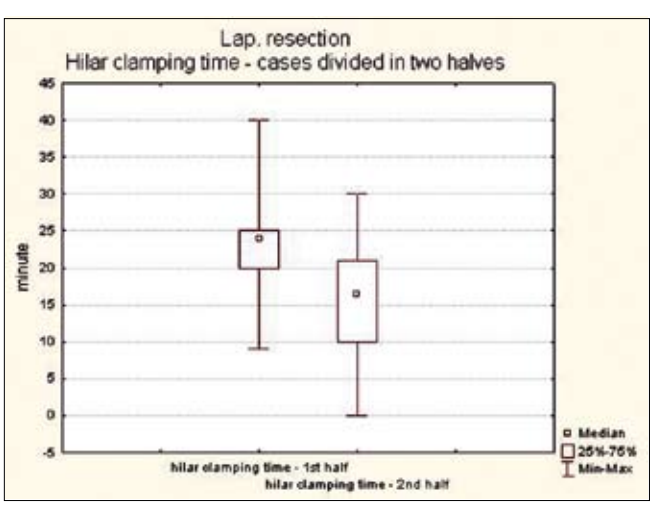
Comparison of the histological findings is not the main aim of the study, but we present the results of the histology to complete the whole presentation. The histology in the LR group is shown in detail in table 6. The major type of renal tumors in OR was CRCC. It was present in 52 (83.9%) cases from the OR group. The others in OR were papillary renal cell carcinoma (PRCC) (6 / 62, 9.6%), oncocytoma (3 / 62, 4.8%), and one leiomyoma. CRCC was also the major type in the LR group (36 cases, 58.1%). The others were PRCC (14 / 62, 22.6%), angiomyolipoma (7 / 62, 11.2% – one epithelioid angiomyolipoma, two with minimal fat), and oncocytoma (3 / 62, 4.8%). CRCC was statistically significantly more frequent in the OR group (83.9 *vs.* 58.1%, Fischer's exact test p = 0.01339). We are not able to explain the higher number of PRCC in the first half (38.7% *vs.* 6.4%) and angiomyolipomas in the second half of LR.



Graph 1. Comparison of hilar clamping time in LR and OR group.



Graph 2. Comparison of operation time of the former (31 cases, 9/2004 to 8/2006) and later group (31 cases, 9/2006 to 12/2008) of LR.



Graph 3. Comparison of warm ischemia (clamping) time of the former (31 cases, 9/2004 to 8/2006) and later group (31 cases, 9/2006 to 12/2008) of LR.

DISCUSSION

Our study verified our premises and the results of other authors [15, 16], that laparoscopic resection (LR) has a lot of disadvantages in comparison to open resection (OR). We don't want to discuss the constituent steps of the procedure here. Of course, all surgeons

Table 6. Histology of the laparoscopic resection group.

		Together		1st part		2nd part	
		Number	%	Number	%	Number	%
Malignant		52	83.9	28	90.3	24	77.4
	CRCC	36	58.1	16	51.6	20	64.5
	MCRCC	2	3.2	0	0	2	6.5
	PRCC type 1	13	21.0	12	38.7	1	3.2
	PRCC type 2	1	1.6	0	0	1	3.2
	unclassified RCC	1	1.6	0	0	1	3.2
Benign		10	16.1	3	9.7	7	22.6
	oncocytoma	3	4.8	1	3.2	2	6.5
	angiomyolipoma	7	11.3	2	6.5	5	16.1
Together		62	100	31	100	31	100

Notes: CRCC – clear renal cell carcinoma, PRCC – papillary RCC, MCRCC – multilocular cystic RCC

continuously integrate improvements to the LR as it is still a rapidly emerging surgery. For example, usage of tissue sealants and anchoring of the suture with clips instead of an intracorporeal suture. These improvements enable the resection of more complex tumors and they improve the results of the LR. LR however, has a higher ischemia time and more complications than OR. The values of complications decrease with the number of operations however, values remain consistently better in OR. LR need a super-specialized surgeon. Here we have to translate the word "challenging" used in literature in context with LR. In this context, it means technically very difficult, with high risk of perioperative problems with very limited tools for solving these problems in comparison with open surgery. Only one main advantage of LR remains – the minimal invasiveness of this procedure with a speedy recovery and fast return to all normal life activities. We still only recommend LR in highly selected cases with regard to the dexterity of specific surgeons. Less experienced surgeons should expect a longer ischemic time and should start with less complex, exophytic, small-masses [17]. OR remains the standard in nephron sparing surgery for us. We have compared our results of LR with the results of our colleagues abroad (see table 8). We were also surprised to find that our results are comparable. Of course, in some series, more complex tumors were dealt with. However, we think the proper selection of tumors appropriate for LR is the first and most important step for good results after LR. Less skilled surgeons can't treat a more complex tumor.

Now we want to stress some details regarding LR. We think that urgent nephrectomy for complications must be considered to be a very poor result of surgery and we have to cautiously avoid it. We have never had to perform nephrectomy during an operation. We prefer to convert the operation in case of bleeding and we try to save the kidney. But nephrectomy is repeatedly described in literature as a solution as well. Nephrectomy was performed in 0.8% (1/123) [17], 1.3% (2/76) [16], 1.7% (1/60) [9], 1.9% (8/425) [6], and even 3.6% (4/110) [10] according to other authors. Weizer

Table 7. Comparison of our results of laparoscopic resection with results of other authors.

Author	No. of cases	Age	Mean tumor size (min)	Time of operation (min)	Ischemia time (min)	Blood loss (ml)	Transfusion rate (%)	Conversion (%)	Hospital stay (days)	Total complications (%)	Positive margins (%)
Gill 2006 [15]	771	59.4	27.0	201.0	30.7	300.0	5.8	2.1	3.3	26.8	2.9
Venkatesh 2006 [17]	123	58.2	26.0	204.0	26.8	269.0	UK	2.4	3.3	20.6	2.5
Weld 2006 [9]	60	56.3	24.0	179.3	26.9	225.5	1.7	0.0	2.7	30.0	0.0
Häcker 2007 [18]	25	60.4	26.2	211.7	28.9	177.4	0.0	0.0	8.3	8.0	0.0
Nadu 2007 [12]	110	62.0	39.0	100.0	30.0	510.0	UK	3.0	UK	15.8	3.6
Desai 2008 [19]	80	65.1	22.0	138.0	UK	135.0	3.7	UK	2.8	21.0	10.0
Gong 2008 [16]	76	60.1	28.7	225.1	32.8	211.9	11.8	7.9	2.5	22.4	1.3
Porpiglia 2008 [11]	90	56.3	31.2	116.6	27.1	175.7	1.1	0.0	UK	24.4	3.3
Pyo 2008 [10]	110	62.0	24.0	199.7	35.0	260.0	0.0	3.6	2.6	4.5 (major)	0.0
Weizer 2008 [13]	174	59.0	24.0	188.0	29.2	200.0	UK	4.0	2.0	36.0	3.0
Simmons 2009 [6]	425	59.9	31.0	210.0	32.0	241.0	UK	1.9	3.4	29.6	0.7
Hora 2009	62	61.6	25.6	111.8	18.4	199.5	6.5	4.8	7.7	27.4	4.8

Notes: Abbreviations: UK = unknown. Part of patients in [6] is included in [15] part of patients in [16] is included in [9]. In our results, complication rate includes positive margins as well.

et al. [13] converted the operation in 4.0% (7/174) and they performed nephrectomy in 3.4% (6/174). We think higher blood loss is an indication for conversion as well as to reduce the need for administering a transfusion. Of course, in large vessel injury, blood loss can be extremely high, even up to 3,500 ml [13]. We performed a nephrectomy in only one case, on the 15th postoperative day, see Fig. 2. The surgeon on-call dealing with this complication decided on a revision, but embolization would have probably been a better option. We are convinced that OR in this case would have saved the kidney. By re-operation, another and better option for solving postoperative bleeding is super selective embolization. Porpiglia et al. [11] had to solve postoperative bleeding in 7.8% (7/90) – three underwent surgery, three underwent selective arterial embolization, and one was managed conservatively with blood transfusions. Gill et al. [15] in an analysis of 771 cases of LR from three larger referral centers found the need for embolization in 1.3% (10/771), re-exploration in 1.7% (13/771), and nephrectomy in 0.4% (3/771). Pyo at al. [10] indicated embolization in 0.9% (1/110).

The excellent control of the tumor is the most important goal of resection. On the basis of our experience, LR has, due to procedural reasons, a higher risk of positive margins. Main reasons are following: There are in LR more complicated elevation of the resected tumor from the bed, more complicated suction of bleeding, access of instruments from only one direction without the possibility to resect sloping deep to the kidney, it is very difficult to re-resect the deep part of the bed during the resection, worse visualization of the margin of the kidney and the tumor by the camera, which has limited resolution. Furthermore, the specimen can be first visualized after finishing the whole procedure and the extraction of the specimen from the abdomen cavity etc. So we are surprised at the very good oncological results in the literature. Maybe slowly growing tumors are resected with OR and the diversity of oncological results in comparison with OR will require a longer follow-up. Yet OR is a solution for positive margins. The surgeon must carefully check the specimen of the resected tumor (only via camera of course). If a residual tumor is suspicious, a re-resection is recommended. But in this case LR has large disadvantages as mentioned earlier (the specimen can be checked only in the abdominal cavity and a detailed direct check with the eyes can't be done until completing the procedure and removal of the specimen through the abdominal wall). The positive margins described by pathologists are not an indication for immediate reoperation. Why? Positive surgical margins following LR don't necessarily indicate residual disease. So instead of re-exploration, vigilant monitoring can be an option [21].

In recent years, we have witnessed the introduction of robotic surgery in urology, including LR. Unfortunately, we have to this date, only a limited number of studies. Robotic resection is a developing procedure, and it is technically feasible and safe; it can produce results comparable to LR though with a longer warm ischemia time than LR. Cost and assistant control of the renal hilum are additional disadvantages [21, 22]. The main disadvantage at our institution is that we don't have the robotic daVinci system yet.

CONCLUSIONS

LR at our institution has a significantly higher ischemia time and occurrence of complications (perioperative and postoperative bleeding) than OR. Values decrease with the number of operations (operating time, warm ischemia time, and complications), however values continue to remain better in OR. We were surprised that our results were comparable with the results of the "center of excellence". What is the reason for the relatively good results at our institution? The careful selection of tumors (at our institution we only indicate less complicated cases – exophytic tumors with good access for laparoscopic instruments) and super specialization of the surgeon. We still recommend LR only in highly selected cases with respect to the dexterity of specific surgeons. OR still remains the gold standard in nephron sparing surgery. We hope robotic surgery will improve the results of laparoscopic surgery in the near future.

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