Clinical and paraclinical evaluation of partial nephrectomy using laparoscopy and open surgery in dogs: new suturing technique

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Summary

Partial nephrectomy, using open surgery or laparoscopy, is a standard surgical approach to treat renal disorders. The objective of this study was to compare and evaluate the feasibility and safety of laparoscopic partial nephrectomy using figure eight ligation technique. Mixed-breed dogs were randomly dedicated for partial nephrectomy using laparoscopy (n=6) and open surgery (n=6). During 30 days after operation, clinical, hematological and ultrasonographic findings, intra- and post-operative complications, operation and ischemia times, urine analysis and incision length were recorded. Operations were performed successfully and dogs recovered without serious complications. All clinical and hematological findings were within normal range. Comparing two experimental groups, operation time and length of incisional scar were longer in open surgery and ischemia time was longer in laparoscopy ($P<0.05$). In conclusion, using figure eight ligation, laparoscopy seems to be safer, more feasible, less time consuming in association with less bleeding for partial nephrectomy compared with conventional open surgery in dog.

Key words: Dog, Laparoscopy, Open surgery, Partial nephrectomy

Introduction

Partial nephrectomy is the standard surgical technique with encouraging outcomes to deal with renal failures such as traumatized kidneys and focal tumors. Although radical nephrectomy is easier and carries less post-operative complications, partial nephrectomy is always recommended because of its potential to preserve part of the renal function, especially in bilateral renal disorders (Becker *et al*., 2009). The first open partial nephrectomy in human was performed in 1984 to remove a perirenal fibrolipoma (Wells, 1984). The first laparoscopic partial nephrectomy in animals was reported in pig in 1993 (Mcdougall *et al*., 1993). Using laparoscopy, two-thirds of the kidney volume can be removed without danger in pigs (Kairemo *et al*., 1996). Partial nephrectomy using laparoscopy has potential benefits to open surgery including decreased morbidity, shorter hospital stay and convalescence and preservation of renal function (Aron *et al*., 2006). The purpose of this study was to evaluate and compare partial nephrectomy using laparoscopy and open surgery along with simple and easy figure eight ligation.

Materials and Methods

Present study was approved by the Animal Ethics Committee of Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran. Large mixed-breed dogs (n=12; 23 kg body weight, 1-2 years old) were selected for this experiment. Prior to the surgery, intravenous pyelography was performed at 0, 5, 10, 20, and 40 min after injecting Iohexolas contrast media (240 mg/ml; Omnipaque^{TM}) at the dose of 1 ml/kg. Complete blood count (CBC) and urine analyses were evaluated to ascertain animal health and normal kidney function. Food was restricted for 8 h prior to surgery and cefazolin (22 mg/kg) was administrated IV as a pre-operative prophylaxis antibiotic before inducing anesthesia. Dogs were sedated with acepromazine (0.05 mg/kg) and general anesthesia was induced by combination of ketamine HCL (10 mg/kg) and diazepam (0.2 mg/kg) and maintained by inhalation of isoflurane in oxygen (1.5%) through anesthetic machine. Dogs were randomly assigned into two equal groups. For laparoscopic partial nephrectomy, dogs were placed in right lateral recumbency. The first trocar was inserted via 10 mm incision left lateral to the umbilicus. Then pneumoperitoneum was established by connecting the trocar to the high flow insufflators using carbon dioxide. The 10 mm 0 degree rigid camera connected to a light source was inserted into the abdomen. The second, third and fourth 5 mm trocars were placed in proximal and left lateral side to the first portal (Fig. 1). The left kidney's hilus was identified and renal artery was exposed by dissecting the perihilus fat and attachment (Fig. 2). The renal artery was clamped with vascular hemoclamp. In this study for resection of lower pole of kidney, figure eight ligature was performed. The lower pole of kidney parenchyma

was ligated by figure eight technique with vicryl no 1 suture material that joined to a long straight needle. For performing this technique the needle was passed through the middle part of the lower pole of renal parenchyma then figure eight ligature was performed and tightened, next the lower pole of kidney was resected. In this technique capsule did not incise and ligature was placed over renal capsule (Figs. 3-5). After resection of lower pole, kidney was inspected for bleeding. The resected portion (15%) of kidney was removed in a bag through 10 mm portal. At the end, trocar incisions were sutured in a routine manner. Antibiotic and analgesic agent were administrated after surgery. In open surgery, dogs were positioned in dorsal recumbency and midline incision was performed. After identification of left kidneys hilus, renal artery was clamped then lower pole of kidney was resected after placement of figure eight ligature. Antibiotic and analgesic medications were administrated similar to laparoscopic group.

Surgical parameters such as operation time, ischemia time and skin suturing time were recorded. Ischemia time was calculated from renal artery occlusion by hemoclamp to the release of the hemoclamp. Complete blood count, urine analysis and clinical parameters including heart rate, respiratory rate and body temperature were measured before and on days 1, 3, 7 and 30 after surgery. Intravenous pyelography was performed on day 30. Any clinical complications were monitored on a daily basis.

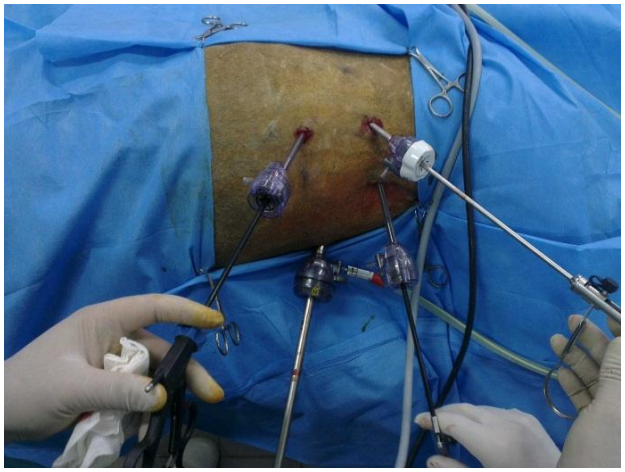

Fig. 1: Portal insertion

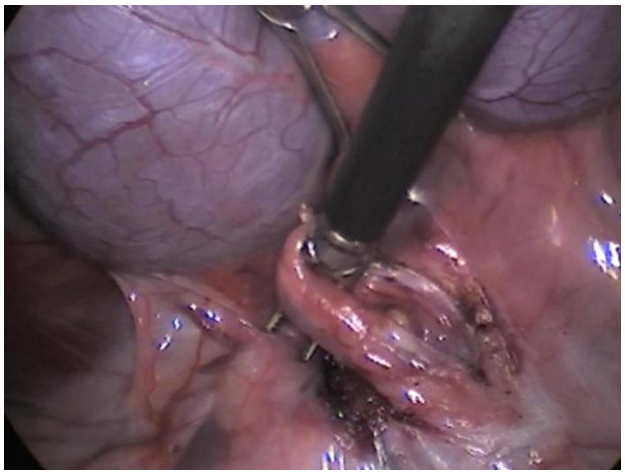

Fig. 2: Renal artery dissection

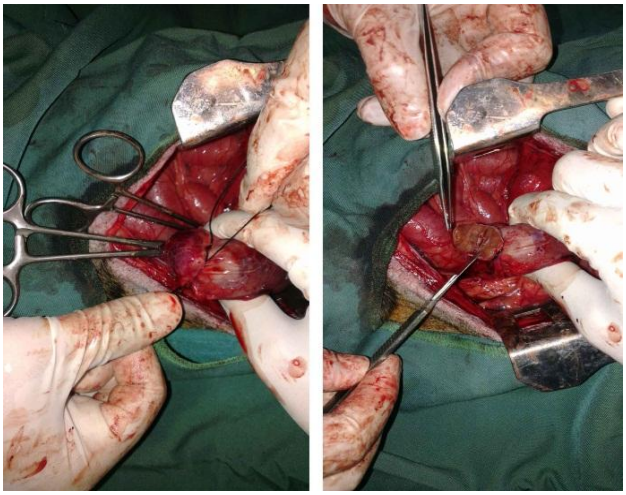

Fig. 3: Figure eight suture and tissue resection in open technique

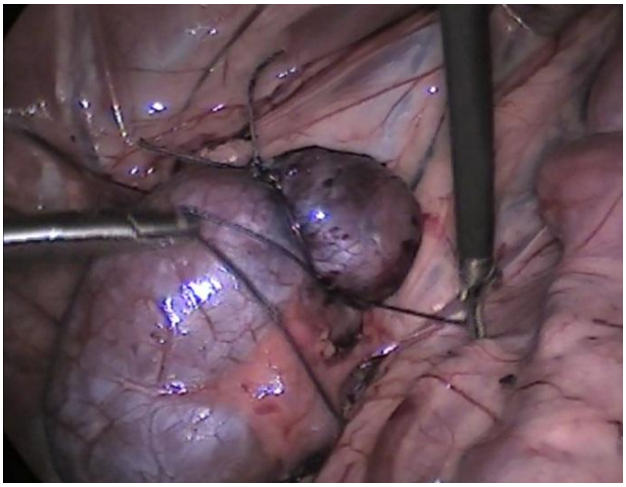

Fig. 4: Figure eight suture in laparoscopic technique

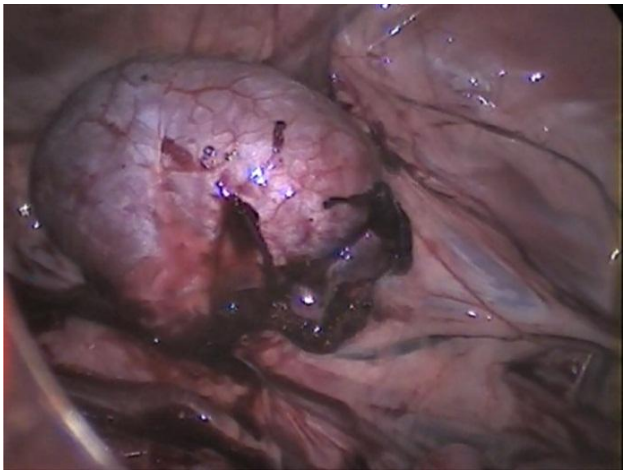

Fig. 5: Figure eight suture and tissue resection in laparoscopic technique

Results

Surgery was performed successfully and dogs recovered without serious complications. No intra-operative complication occurred in any groups. No hemorrhage or urinary leakage was observed after operation and no cases required re-operation. There was not any post-operative complication except one case in open surgery group that wound infection and suture dehiscence occurred. Operation time was different between laparoscopy (37.3 ± 0.80 min) and open surgery (49.83 ± 1.44 min; Table 1; P<0.05). Ischemia time was different between laparoscopy (18.7 ± 0.66 min) and open surgery (12.5 ± 0.42 min; Table 1; P<0.05). Skin and muscle suturing time was different between laparoscopy (204.5 ± 0.80) and open surgery (610.3 ± 13.87; Table 1; P<0.05). All clinical findings such as heart rate, respiratory rate and body temperature and hematological parameters were within normal range, pre- and post-operations (Tables 2 and 3). Urine analyses were normal except on day 3 after surgery when slight increase in number of RBC was noticed in all dogs. Pre-operative IVP showed that left kidneys in all dogs were normal. IVP on day 30 after laparoscopy showed normal function of all left kidneys. However, there was tubular damage in two cases following open surgery (Fig. 6). Figure eight technique suture was not associated with any complications.

Discussion

The purpose of this study was to elucidate advantages and disadvantages of partial nephrectomy following laparoscopy and open surgery using figure eight ligation. In present study, clinical and paraclinical findings were similar and there were no mortality and intra- and post-operative complications between laparoscopy and open surgery. There were potential benefits to performing laparoscopic partial nephrectomy including decreased morbidity, decreased operative blood loss, shorter hospital stays, convalescence, decreased post-operative infection and preservation of renal function (Uzzo *et al*., 2001; Aron *et al*., 2006; Gill *et al*., 2007). Because of

Fig. 6: IVP in day 30 after surgery (0&5&40 min left to right). The sign shows remains of iohexol (arrow) after 40 min of injection in kidney (tubular damage)

Table 1: Surgical parameters in partial nephrectomy using laparoscopy and open surgery. Data were presented as mean±SEM

Parameters	Laparoscopy	Open surgery
Operation time (min)	37.3 ± 0.80[a]	49.8 ± 1.44[b]
Ischemia time (min)	18.7 ± 0.66[a]	12.5 ± 0.42[b]
Skin and muscles suturing time (s)	204.5 ± 7.14[a]	610.3 ± 13.87[b]

[a, b] Values within rows with different superscripts differ (P<0.05)

Table 2: Pre- and post-operative clinical findings following partial nephrectomy using laparoscopy and open surgery (day 0= day of operation). Data were presented as mean±SEM

Parameters	Laparoscopy			Open surgery		
	Day -1	Day 1	Day 30	Day -1	Day 1	Day 30
Heart rate	99.7 ± 1.80	97.8 ± 1.37	102.0 ± 2.47	101.3 ± 1.76	98.3 ± 1.30	103.0 ± 1.34
Respiratory rate	18.2 ± 0.74	18.7 ± 0.98	18.5 ± 0.61	18.0 ± 0.36	18.2 ± 0.54	20.3 ± 0.91
Temperature (°C)	38.7 ± 0.07	38.5 ± 0.05	38.6 ± 0.06	38.7 ± 0.09	38.8 ± 0.08	38.7 ± 0.04

Table 3: Pre- and post-operative blood analysis following partial nephrectomy using laparoscopy and open surgery (day 0= day of operation). Data were presented as mean±SEM

Parameters	Laparoscopy			Open surgery		
	Day -1	Day 1	Day 30	Day -1	Day 1	Day 30
WBC	8.2 ± 0.59[a]	12.4 ± 1.17[b]	8.7 ± 0.34[a]	8.9 ± 2.52[a]	16.9 ± 2.10[b]	8.4 ± 0.67[a]
RBC	7.3 ± 0.45	6.5 ± 0.29	6.5 ± 0.36	7.2 ± 0.33	5.6 ± 0.33	5.9 ± 0.17
HGB	15.6 ± 1.61	14.5 ± 1.09	13.5 ± 0.90	16.4 ± 1.13	13.2 ± 0.65	12.3 ± 0.81
HCT (%)	46.4 ± 2.95	47.2 ± 2.30	44.9 ± 1.53	47.8 ± 2.38	38.3 ± 2.10	44.2 ± 1.59
PLT	292.5 ± 15.50	293.8 ± 17.56	271.7 ± 11.75	300.2 ± 9.76	303.8 ± 24.46	294.7 ± 15.44
Lymph (%)	20.7 ± 3.07	20.7 ± 1.25	19.7 ± 1.14	23.0 ± 1.86	23.3 ± 2.75	21.3 ± 0.55
Mon (%)	2.0 ± 3.07	3.5 ± 0.56	3.5 ± 0.50	2.3 ± 0.42	2.3 ± 0.42	3.3 ± 0.49
Eos (%)	2.3 ± 1.03	2.2 ± 0.30	2.0 ± 0.25	3.2 ± 0.47	1.5 ± 0.34	1.8 ± 0.30
Neut (%)	75.3 ± 1.49	73.7 ± 1.28	75.5 ± 1.05	71.3 ± 1.80	72.7 ± 2.98	73.2 ± 0.79
Bas (%)	0.3 ± 0.21	0	0	0.2 ± 0.01	0.2 ± 0.01	0.3 ± 0.21

image amplification and illumination (Remedios *et al*., 1996; Michael *et al*., 2001), laparoscopy permitted an improved visualization and identification of abdominal organs compared to open surgery.

In this study we introduce new figure eight ligature technique for ligation of renal parenchyma. This technique is safe and feasible and more rapid than conventional method. The speed of this method is relatively high because renal capsule was not incised and figure eight ligature was placed over renal capsule. As a result, incision and suturing of capsule has been omitted in this technique and the duration of ischemia and operation time decreased. The extent of renal damage after arterial occlusion depends on the duration of ischemic insult (Lyrdal, 1975; Chiu *et al*., 1999; Brasile *et al*., 2001). Several clinical studies suggested that the maximum period of ischemic time for preservation of renal function should not exceed 20 min (Marberger *et al*., 2007; Thompson *et al*., 2007; Lane *et al*., 2008; Funabashi *et al*., 2009). Kidney cannot tolerate ischemia beyond 30 min (Leary *et al*., 1963; Ward, 1975; Baldwin *et al*., 2004; Bhayani *et al*., 2004; Yossepowitch *et al*., 2006). This time frame is very critical in renal transplantation surgery where ischemic time has to be minimized to reduce renal damage. Data derived from non-heart beating donors describing renal tolerance to ischemia revealed that ischemic time of <20 min significantly reduced post-transplant kidney damages (Nishikido *et al*., 2004). Although early observation in dog models showed that there may be substantial variation in kidney tolerance for up to 2-3 h of ischemia (Handley *et al*., 1957). In present study the mean time of ischemia in laparoscopic group was longer than open surgery group but it was still within acceptable limits in both groups.

Operation time is another important factor affecting intra- and post-operative complications. In the present study, operation time in laparoscopy was shorter than open surgery because suturing of incisions was omitted in laparoscopic procedure. Less operation time in this study compared to human model study was probably due to excessive fat around human kidneys (Robinson *et al*., 2003; Schiff *et al*., 2005). Skin and muscle incision suturing time in laparoscopic group was significantly shorter than open surgery group which causes less injury and trauma in addition to less manipulation. In open surgery technique incision line should be closed in 3 layers suturing but in laparoscopy portal incision suturing is performed just by one interrupted pattern suture. Accordingly, patients experienced less pain following laparoscopy (Perla *et al*., 2006).

In present study, IVP results in both groups were normal except one case of open surgery group in which tubular damage was reported on day 30 after surgery. This might be due to aggressive approach and excessive tissue manipulation in open surgery.

All clinical parameters such as heart rate, respiratory rate and body temperature in addition to homological factors were within normal ranges which were similar to previous reports in dog (Latif *et al*., 2007). Hematological parameters did not change significantly and all of the pre- and post-operative results are within normal range. Urine analysis results showed slight increase in number of RBC in urine sample of all dogs after surgery. This was predictable due to the nature of surgical procedure.

Hemorrhage is one of the most important intra- and post-operative complications in partial nephrectomy. One of the advantages of figure eight ligation technique is that bleeding is effectively controlled throughout operation. There was one case of post-operative wound infection following open surgery, possibly due to long surgical incision. Overall infection rates were 4.1% in open surgery and 2.11% for laparoscopy indicating that laparoscopy can reduce hospital-acquired infection for up to 50% compared to open surgery (Barclay, 2008).

In conclusion, the safety and feasibility of laparoscopy for partial nephrectomy along with figure eight ligation was approved. Laparoscopic partial nephrectomy has several operative and post-operative advantages over conventional technique. Figure eight ligation technique may be considered as a method of choice for partial nephrectomy due to reduction in operation time.

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