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Comparison of Laparoscopy-Assisted Partial Nephrectomy Using Digital Compression versus Purely Laparoscopic Nephrectomy Using Vascular Pedicle Clamp in a Porcine Model

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ABSTRACT

***Background and Purpose*: Laparoscopic partial nephrectomy raises a number of technical issues, particularly in the control of bleeding. We compared digital compression during hand assistance with a vascular clamp.**

***Materials and Methods*: Laparoscopic transperitoneal bilateral lower-pole partial nephrectomy was performed on six pigs, with a vascular clamp being used on one side and digital pressure through an Omniport or Lapdisk on the other. The pigs were then euthanized and the kidneys harvested for histologic examination.**

***Results*: Good hemostasis was obtained regardless of the technique. However, the estimated blood loss was significantly greater with digital compression (96.7 versus 9.6 mL). There were no significant micropathological differences in the kidneys. The surgeons rated suture tying and placement much easier with the purely laparoscopic technique.**

***Conclusions*: Both techniques are feasible. In experienced hands, the purely laparoscopic technique takes no longer than the hand-assisted technique and is associated with less blood loss, easier suturing, and better cosmesis. However, long-term follow-up is needed before clinical use can be contemplated.**

INTRODUCTION

THE SUCCESS OF LAPAROSCOPIC SURGERY for ablative procedures on the kidneys has led to extension of this method to technically more complex organ-preserving operations. Laparoscopic partial nephrectomy has been performed successfully in various ways for benign and malignant diseases. However, this approach raises specific issues in hemostasis, vascular control, control of the collecting system, and technical difficulty when using only laparoscopic instrumentation. The introduction of hand assistance for transperitoneal laparoscopy has been reported to provide a more rapid and a safer technique for difficult laparoscopic cases without sacrificing improvements in convalescence. The objective of our study was to compare the efficacy and the ease of the two techniques and to demonstrate differences in technical feasibility and micropathologic evaluation.

MATERIALS AND METHODS

Laparoscopic transperitoneal bilateral lower-pole partial nephrectomy was performed by the same operator on six pigs with a mean weight of 55 kg. Each pig had a purely laparoscopic nephrectomy on one side and a laparoscopic hand-assisted partial nephrectomy on the other side.

Surgical technique

After general anesthesia and sterile preparation, the pigs were placed in the dorsal supine position. Pneumoperitoneum was

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established with CO_2 to 15 mm Hg by either a Veress needle or an open midline incision with placement of an access device for hand-assisted laparoscopy (Omniport or Lapdisk). For the purely laparoscopic technique, four ports were used: two 10-cm working ports and either a 12-mm or an inflated (closed around the port) Omniport or Lapdisk with a 12-mm port for the laparoscope. An additional 10-mm port was placed in the suprapubic area, above the bladder, for the introduction of laparoscopic vascular clamps. For the hand-assisted technique, an additional working port with a 10-mm access for the 0° or 30° laparoscope was placed. After adequate examination of the intra-abdominal organs, the pig was placed in a right or left decubitus position in order to retract the intestines and obtain a better view of the kidneys.

In the purely laparoscopic technique, scissors with electrocautery were used to incise the peritoneum in the vicinity of the hilum of the kidney. The vascular pedicle was sharply dissected to clearly identify the renal artery and vein. The ureter was identified and retracted laterally. The lower pole of the kidney was then dissected from the peritoneum and posterior attachments in order to release the anterior and posterior surfaces. The vascular clamp was introduced through the most inferior port, and both the renal artery and vein were clamped *en bloc*. The warm ischemia time was then recorded. Lower-pole partial nephrectomy was performed using sharp excision of the parenchyma with scissors. The section of the lower pole was completed progressively from the concavity to the convexity and from the periphery toward the center. After completion of the excision, hemostasis was obtained using a monopolar coagulation device. Then an intracorporeal 0 Vicryl suture was used to reapproximate the raw edges of the kidney over a rolled-up gauze. Following this, the vascular pedicle clamp was removed. If no bleeding was observed, the kidney was allowed to reperfuse, and the renal artery was observed to be pulsating.

For the hand-assisted laparoscopic (HAL) technique, the peritoneum overlying the lateral aspect of the kidney was dissected using scissors and electrocautery. There was no attempt to dissect the renal hilum or the vascular pedicle. When the intracorporeal hand was able to surround the lower pole of the kidney easily, a partial lower-pole nephrectomy was performed using sharp dissecting scissors while applying digital pressure on the kidney. The section of the kidney was performed in a fashion similar to that used for the purely laparoscopic technique. By releasing and then reapplying pressure on the kidney, the actively bleeding vessels were identified and controlled using a unipolar device. This was followed by placing a 0 Vicryl suture to reapproximate the raw edges of the kidney over rolled gauze. Tying was assisted by the intra-abdominal hand. The kidney was then allowed to reperfuse and was dissected and removed for macroscopic and microscopic pathologic evaluation. After completion of both partial nephrectomies, the pigs were sacrificed using intravenous KCl.

Histologic evaluation

Pathologic examination consisted of macroscopic examination of the fresh operative specimen followed by fixation in 10% formaldehyde. The fixed kidney specimens were sectioned on the upper pole (opposite the surgical excision site) and embedded in paraffin and stained with hematoxylin and eosin for light microscopy evaluation. During sectioning, care was taken to include both the cortex and the medulla. The pathologist examining the slides was blinded to the surgical technique.

Assessment of results

The following data were analyzed: wedge resection time (from the time of clamp or digital compression to the end of section of the parenchyma), total resection time with suturing, estimated blood loss (EBL), intraoperative complications, ease of intracorporeal suturing using the laparoscopic *v* the hand-assisted technique, and histologic finding.

RESULTS

All lower-pole partial nephrectomies were performed according to the above-described protocol. No conversion to open surgery was required. Good hemostasis of the parenchyma was obtained regardless of the technique used. No intraoperative complications or deaths were observed. No differences were seen in oxygen saturation or heart rate. However, EBL was significantly higher with digital compression versus laparoscopic pedicle clamping (96.7 versus 9.6 mL). Wedge resection time and total resection time with suturing was not statistically different (Table 1). There were no significant micropathological differences between the groups. Microscopic evaluation showed no evidence of acute tubular necrosis but did reveal mild to moderate vascular congestion in both groups. There were normal-appearing tubules in both groups and occasional proteinaceous casts in both groups. All these changes appeared to be reversible.

The surgeons rated suture tying and placement much easier in the purely laparoscopic technique than in HAL, possibly because of space restriction. It appeared that hand assistance did not improve suturing or tying intracorporally.

DISCUSSION

Laparoscopic partial nephrectomy is a technically more complex operation than a laparoscopic radical nephrectomy because

Table 1. Comparison of Purely Laparoscopic and HAL Partial Nephrectomy

	Vascular clamp	*Digital compression*
Mean wedge resection time (range) (min)	3.8 (2–6)	4.5 (3–6)
Total time (range) (min)	15.3 (10–18)	20.2 (14–35)
Mean EBL (range) (mL)	9.6 (5–15)	96.7 (50–150)

of the difficulty of controlling hemorrhage. Few studies have been published in either humans or animals describing various techniques of laparoscopic partial nephrectomy.[1–7] Winfield and colleagues[1] performed the first laparoscopic partial nephrectomy for benign disease in 1992. They used a technique developed by McDougall and coworkers in a porcine model.[3] In these animal studies, successful partial nephrectomies were performed using a plastic cable as a renal tourniquet and electrosurgical scissors for renal transaction. Hemostasis was achieved with argon beam coagulation. Wolf and associates[8] compared open and laparoscopic hand-assisted nephron-sparing surgery and showed an advantage using a minimally invasive technique. Winfield and colleagues[4] had a similar result, with a reduction of operative morbidity and duration of convalescence compared with open surgery. Other studies have shown the feasibility of laparoscopic partial nephrectomy in both humans and animal models.[2–5]

Numerous technologies have been studied for laparoscopic partial nephrectomy because of the suboptimal clinical results and technical difficulty of the procedure. Hand-assisted laparoscopic techniques are becoming more widespread because of the shorter learning curve and alleged ease of kidney manipulation and perhaps suturing.[9–12] To our knowledge, no group has compared hand-assisted digital compression of the kidney with laparoscopic clamping of the vascular pedicle in terms of feasibility, EBL, or tissue damage. The pig was chosen as the animal model for this experiment because, as demonstrated by Sampaio and colleagues,[13] the morphometric and anatomic characteristics of its kidneys are similar to those of human kidneys. The technique classically described in open surgery with bidigital compression of the parenchyma can be transposed directly to HAL. In contrast, clamping of the vascular pedicle is more effective in controlling hemorrhage but carries a risk of warm ischemia time with associated kidney damage and tubular necrosis as well as vascular trauma.[3] Moreover, digital compression may produce some warm ischemia of the affected region and may produce total ischemia with kinking of the vascular pedicle during hand manipulation. Our study showed no difference in kidney damage in the two groups, as judged by macroscopic and microscopic evaluation.

In our study, the blood loss was significantly lower in animals having vascular pedicle clamping. This is attributed to the total occlusion of the blood supply to the kidney, producing warm ischemia. Digital compression resulted in much greater blood loss, poorer field visibility, and more difficult control of the bleeding parenchyma and suture placement. Nevertheless, both groups had good outcomes, and no complication or death occurred in either group. This result would favor a purely laparoscopic approach with good technique and suturing. Moreover, we experienced more difficulty with knot tying and suture placement in HAL because of the limited working space and less expeditious suture manipulation. Further survival studies will need to be done to show further advantages of a purely laparoscopic technique with increased experience.

CONCLUSION

Nephron-sparing surgery can be performed in the pig using a purely laparoscopic vascular pedical clamping technique or hand-assisted digital compression without significant difficulty. In trained hands, the purely laparoscopic technique produces similar resection times with less blood loss, easier suturing, a smaller abdominal incision, and no noticeable difference on pathologic examination. This study would need to be extended to survival procedures and specifically address the collecting system and internal urine diversion. These techniques can be applied to partial nephrectomies in the human.

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