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Technical Report

A Canine Model of Laparoscopic Segmental Liver Resection

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ABSTRACT

Laparoscopic hepatectomy has been recently proposed for the treatment of liver tumors, however there is a lack of experimental models to study surgical technique and the metabolic reactions after this procedure. The dog is an important animal for research but the laparoscopic hepatectomy model is not well established in this animal. We describe the surgical laparoscopic technique of left liver segmentectomy in the dog and the preliminary results of this procedure. Female dogs weighting more then 15 kg were used. Four transversal abdominal incisions (two of 1 cm and two of 0.5 cm) were made for the introduction of the video camera and the other laparoscopic instruments. The liver was inspected and the left lobe was mobilized through incision of the left triangular hepatic ligament. The vascular pedicle corresponding to the left medial lobe (corresponding to segment II) was identified, dissected, and clamped, delimiting a correspondent ischemic area. The hepatic parenchyma was divided according to the previous delimitation with minimum bleeding. The segment of the liver was then removed through an enlarged abdominal incision. The incisions were closed by continuous suture. The mean time of the procedure was forty minutes. We observed normal clinical evolution without any sign of complications due to the hepatic resection, and normal augmentation of body weight on follow-up of more than 3 months. Left hepatectomy in the dog is a viable procedure and may serve for surgical training and development of research projects in this field.

INTRODUCTION

ADVANCES IN LAPAROSCOPIC SURGERY and the development of new laparoscopic instruments such as the harmonic scalpel and endoscopic vascular staplers have extended its application to liver surgery. The advantages of this procedure over open hepatectomy include smaller incisions, reduction in postoperative pain, more rapid convalescence, better metabolic and immune responses, shorter hospital stay, and less morbidity.

Laparoscopic hepatectomy has been indicated for the treatment of benign liver conditions such as hepatic adenoma, hydatid cyst, and hemangioma. However, because of technical difficulties such as control of hemorrhage from the transection plane and large intrahepatic veins, laparoscopic hepatectomy is not a common procedure.

There is not an established canine experimental model for research in laparoscopic hepatectomy. The dog is one of the most used animals in experimental research and has a reasonable size for laparoscopy. Also, the meta-

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bolic and immunologic reaction of the dog after surgery is close to that in human beings. Laparoscopic liver resection has not been extensively described in dogs.

Improvements in the understanding of the intrahepatic anatomy have increased the indications for segmental liver resections. Segment-oriented resection allows maximal conservation of normal liver parenchyma while clearing tumor. We describe a canine laparoscopic model of segmental liver resection.

MATERIALS AND METHODS

Animal preparation

The animals were fasted 12 hours before the procedure. The dogs were premedicated with ketamine 20 mg/kg, acepromazine 0.1 mg/kg, and atropine 0.04 mg/kg IM. After induction with pentobarbital 20–30 mg/kg intravenously, anesthesia was maintained with isoflurane. An endotracheal tube was inserted and connected to a ventilator with a tidal volume of 15–20 mL/kg at a rate of 12–16 breaths/min. Inspired O2 concentration was maintained at 100%. Pulse oxymetry, blood pressure, and four-lead electrocardiogram were monitored during surgery. Antibiotics (cefazoline 1 g) were given preoperatively and postoperatively. Normal saline was given during the procedure.

Operative technique

The dog is placed in the supine position, and the abdomen is prepped with povidine and draped. An incision of 1 cm is made 3 cm inferior to the umbilicus for insertion of a 11-mm laparoscopic port sheath under direct vision. Pneumoperitoneum with CO_2 is then created with pressure of 14 mm Hg. One 12-mm and two 5-mm laparoscopic port sheaths are placed through the anterior abdominal wall under direct vision in the following locations: right upper quadrant along the anterior axillary line (for the 5-mm liver retractor), right flank (for the surgeon's 5-mm grasping forceps) and left lower quadrant (for the surgeon's electrocautery scissors, staplers, and harmonic scalpel). After placing the animal in the reverse Trendelenburg position, the right liver lobes are retracted in a cephalad direction using a 5-mm liver retractor inserted through the right upper quadrant. This maneuver allows exposure of the portal pedicle from the left lateral segment of the canine liver (Fig. 1). The segmental portal pedicle is then dissected and ligated between metallic clips (Fig. 2). This ligature results in an ischemic area corresponding to the liver area to be removed (Fig. 3). The liver parenchyma including the segmental hepatic vein is initially divided with monopolar electrocautery scissors and/or ultrasonic scalpel (UltraCision) followed by application of the vascular linear stapler (Ethicon Endosurgery, Cincinnati, Ohio) (Fig. 4). All of these steps are performed without clamping the porta hepatis (Pringle maneuver). Once the liver resection is completed the surgical specimen is brought out through a minilaparotomy incision made by extending the right upper quadrant incision. The abdominal cavity is irrigated and suctioned, and the incisions are closed in two layers. The dog is then allowed to recover from anesthesia and is followed up for three months.

RESULTS

Five consecutive female dogs with a mean weight of 17 $\pm$ 1 kg underwent successful left segmental liver resection. Average operating time was 40 $\pm$ 12 minutes (range, 30–55 minutes). There were no intraoperative complications. Mean blood loss was 16 $\pm$ 2 mL (range, 10–40 mL). The resected liver segment weighed 62 $\pm$ 11 g (range, 37–97 g). There were no early postoperative complications or deaths. The animals resumed oral food intake immediately after surgery. White blood cell count, hematocrit, and liver function tests did not change postoperatively, except for aspartate aminotransferase (AST), which was elevated twofold immediately after the procedure. We observed normal clinical evolution without any sign of complications due to the hepatic resection, and normal augmentation of body weight at follow-up of 3 months.

DISCUSSION

Successful laparoscopic liver limited resections have been initially reported in a number of small series,[1–3] The first successful laparoscopic anatomical liver resections were reported in 1996.[4,5]

Due to its complexity, laparoscopic hepatectomy requires a program of experimental animal models for the development of new research in liver surgery and for training in clinically applicable surgical techniques. The description of laparoscopic live-donor nephrectomy[6] and the recent development of laparoscopic hepatectomy for living donor transplantation[7] make laparoscopic hepatectomy an attractive approach for this purpose. Thus, it is appropriate for laparoscopic surgeons to learn this technique in large animals before clinical application. With this goal, the current canine study was initiated to promote familiarity with the instruments best suited to the techniques for performing laparoscopic hepatic resections in humans.

A canine model was chosen because it is widely available for experimental study in our country. There is a law that limits the use of the pig in experimental studies in

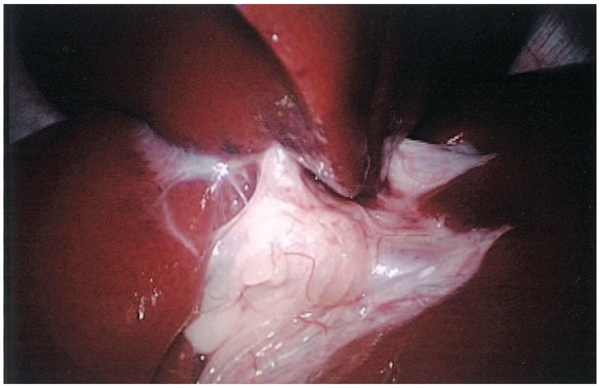

FIG. 1. Exposure of the segmental portal pedicle.

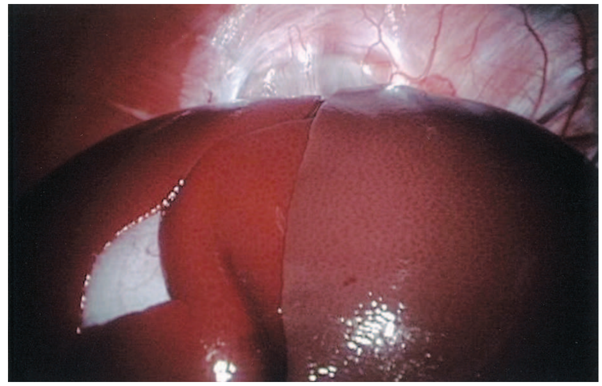

FIG. 3. Ischemic area corresponding to the liver area to be removed.

our city. The dog is a suitable training model for hepatic surgery. However, unlike the human liver, the canine liver has multiple lobes. In the present study, the resection of the left medial lobe of the dog was done to correspond to a segmentectomy II in humans.

Some authors prefer the use of an abdominal lift device to minimize the risk of gas embolism.[8] However, previous experience with this device showed that it creates a tent-shaped rather than a dome-shaped working cavity. The intra-abdominal organs are thus closer to laterally based port sites. Therefore, there is a slightly greater risk for iatrogenic injuries from laparoscopic instruments. In the current series, pneumoperitoneum with CO2 was used without complications. The liver parenchyma was divided with monopolar electrocautery and ultrasonic scalpel with no further difficulty.

The ultrasonic dissector (cavitron ultrasonic surgical aspirator) is a practical instrument for the performance of liver resections, but the permanent suctioning may interfere with the maintenance of pneumoperitoneum, and it was replaced by the ultrasonic scalpel in this canine model.

The direct approach to the corresponding portal pedicle before the hepatectomy permits the previous delineation of the liver segment to be removed, avoiding total hepatic ischemia and reducing liver damage and intraoperative bleeding.[9] The portal pedicle in the dog resembles the human glissonian pedicle but it is visible, can be easily identified, and due to its reduced size can be controlled with standard metallic clips. Another advantage of this technique is that it avoids venous stasis of the small bowel which can be hazardous if porta hepatis clamping is prolonged. The use of the vascular linear stapler is fundamental to the control of the corresponding branches of the hepatic vein. In previous series, serious complications and massive bleeding followed hepatic vein laceration during parenchymal dissection. However, the use of the vascular linear stapler is not always easy and sometimes we can experience some difficulty in the application of this instrument because of the angle of the introductory port, as occurred in the first animal of this series. We observed a decline in operating times, evidencing a learning curve associated with this experimental model. The learning curve seen in the cur-

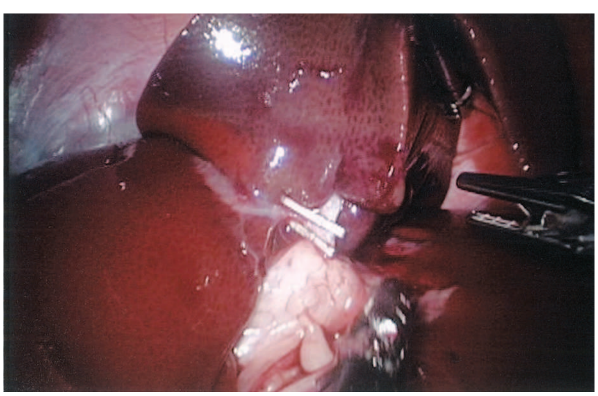

FIG. 2. The segmental portal pedicle is ligated between metallic clips.

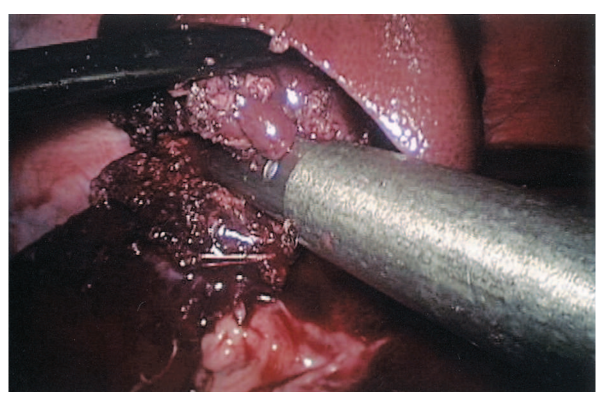

FIG. 4. The liver parenchyma is divided with a vascular linear stapler.

rent study enhances the significance of appropriate training in an animal model. The development of an alternative experimental model in dogs can spread the use in some surgical centers where the pig is not readily available for experimental study. There are very few experimental models for laparoscopic liver resection.[8,10,11]

Laparoscopic left hepatic resection is technically feasible in the canine model. This exercise can serve as excellent preparation for surgeons and help to shorten the learning curve in human applications. We advocate using pneumoperitoneum to gain exposure but gas embolism complications must be assessed in larger series.

Laparoscopic hepatic resection in the dog is a useful training model that can enhance the safety of laparoscopic hepatic resection during the initial phase of clinical application.

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