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ORIGINAL ARTICLE

Comparison between staple and vessel sealing device for parynchemal transection in laparoscopic liver surgery in a swine model

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Abstract

Background. Advancements in technology have allowed laparoscopic surgery to expand into advanced procedures such as liver resection; however, the transection method is debatable. This study was designed to evaluate the feasibility and outcome of laparoscopic liver resection comparing the vessel sealing device (VSD) versus endomechanical stapling devices for parenchymal transection in a swine model. *Materials and methods.* Laparoscopic left hepatectomy was performed in two groups ($n = 7$ in each group) comparing the stapler device with the VSD. The cut surfaces of the liver were evaluated for bleeding and biliary leakage at the time of the operation and 1 week later. The animals were sacrificed 1 week after the operation to determine hemorrhage and bile leakage, and to allow histological evaluation of the liver. Serum liver enzymes were checked before, after, and 1 week postoperatively. *Results.* No evidence of biliary leakage or hemorrhage was noted at the time of the operation and 1 week later for both groups. There was a trend toward an increase in blood loss in the stapled group compared with LigaSure (40 ± 16.4 cc vs 17 ± 3.7 cc, $p > 0.05$). There was also a trend toward shorter transection time in the stapled group compared with the LigaSure group (15 ± 4.1 min vs 21.8 ± 5.3, $p > 0.05$). The instrument cost was significantly higher in the stapled group (720 ± 110 vs 400 ± 50; $p < 0.05$). There was no difference in serial liver enzymes and liver histopathology in the two groups. *Conclusions.* The VSD and endomechanical stapler can be safely and effectively used for parenchymal transection during laparoscopic liver resection. However, using endomechanical staplers is associated with an increase in cost.

Key Words: *liver surgery, laparoscopy, laparoscopic liver resection*

Introduction

Laparoscopic liver surgery (LLS), originally used mainly for diagnostic procedures such as laparoscopically guided liver biopsies [1], has now expanded to include a wide variety of curative procedures. The first laparoscopic liver resection was reported in 1992 [2]. Currently, the majority of laparoscopic liver surgery is being performed at a growing number of institutions [3]. Laparoscopic techniques can now be used to perform liver resections for malignant tumors [4,5] and donor hepatectomies [6,7], among other procedures. Laparoscopic liver resections have the advantage of being minimally invasive, and further expansion of laparoscopic liver procedures is likely [8–10].

Parenchymal transection is a particularly critical stage during LLS. To minimize peri- and postoperative morbidity, the transection technique should be safe and quick. Intraoperative bleeding is recognized as negatively influencing morbidity [11] and recurrence of malignant disease [12,13] after open procedures, and this is likely to occur also after LLS.

The traditional method of transecting liver parenchyma is the ‘finger-fracture technique,’ in which the parenchyma is broken up and divided between the fingers and the palpable parenchymal vascular structures are secured and severed. A refinement of this technique is the ‘clamp-crush technique,’ in which a clamp is used to fracture and divide small sections of the parenchyma before securing and severing the supposedly spared vessels. In addition, vascular inflow to the liver is commonly occluded to reduce blood loss when the parenchyma is transected.

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However, occlusion can cause ischemic injury to the liver and increase the morbidity among the patients.

As improvements of parenchymal transection, new techniques and technology have evolved such as linear stapling cutters, water jet dissectors, ultrasonic dissectors, ultrasonic shears, vessel sealing systems [14–18]. These are now being applied to laparoscopic liver procedures. To date, however, the selection of a technique is based mostly on the surgeon's preference rather than on objective data.

This study aimed to compare the safety and efficacy of the stapling device and the vessel sealing system (LigaSure) using the end points of bleeding, operation time, bile leak, and cost in parenchymal transection during laparoscopic left hepatectomy in the pig liver.

Materials and methods

The study protocol was approved by the Animal Committee of Providence Hospital.

Animal preparation

For this study, 10 piglets (7 in each group) with mean weight 30.8±2.9 kg were used. The animals were fasted overnight with free access to water before the experiment. Anesthesia was induced with an intramuscular (IM) injection of Zoletil forte veterinary (Tiletamin 50 mg/ml and zolazepam 50 mg/ml) 6 mg/kg, Rompun veterinary (xylazine 20 mg/ml) 2.2 mg/kg, and Atropin (atropine sulfate 0.5 mg/ml) 0.04 mg/kg. A peripheral ear vein was cannulated for further induction and maintenance of anesthesia and for fluid administration. Morphine 20 mg and ketamine 100 mg were given as a bolus IV injection. The anesthesia was maintained with a continuous IV infusion of ketamine 0.20 mg/kg/h, pancuronium bromide 0.24 mg/kg/h, and morphine 0.5 mg/kg/h.

Operative technique

The operations were performed with the pigs in a supine position. A 10 mm trocar was introduced below the umbilicus using open techniques, and a pneumoperitoneum of 12 mmHg was obtained with CO_2 insufflation. The laparoscope was introduced, and two additional 5 mm trocars and one 10 mm trocar were placed under direct visualization on each side of the laparoscopic trocar. A handport device was not used.

The parenchymal transection was performed with a linear stapler (US Surgical, Norwalk, CT, USA) or vessel sealing system (LigaSure; 10 mm, Valley Lab Inc., Boulder, CO, USA).

Results

All animals had successful left hepatectomy. There were no intraoperative complications or death. The resected liver segment weighed 132.5 g (range 65–305 g). There were no early postoperative complications or deaths. White blood cell count, hematocrit, and liver function tests did not change postoperatively. We observed normal clinical evolution without any complications owing to hepatic resection at follow-up of 7 days, at which time the pigs were sacrificed. No bile leaks, necrotic segments of liver, hematomas, or intra-abdominal abscesses were found during autopsy.

No evidence of biliary leakage or hemorrhage was noted at the time of the operation and 1 week later for both groups. There was a trend toward an increase in blood loss in the stapled group compared with VSD (40±16.4 cc vs 17±3.7 cc, $p>0.05$) (Table I). There was also a trend toward shorter transection time in the stapled group compared with the LigaSure group (15±4.1 min vs 21.8±5.3, $p>0.05$). The instrument cost was significantly higher in the stapled group (720±110 vs 400±50; $p<0.05$). There was no difference in serial liver enzymes or liver histopathology in either group.

Discussion

Laparoscopic liver surgery (LLS) has gained interest in some centers since the development of newer laparoscopic techniques and instruments. The safety of the procedures could be shown in selected patients and, despite longer operating times, laparoscopy was associated with less blood loss and reduced morbidity, especially in patients with cirrhosis [1–3]. The advantages of LLS are those of minimally invasive surgery. The mean hospital stay is shorter. With adequate training, LLS can be performed with a high success rate and minimal morbidity and mortality. Laparoscopy can be proposed as the primary approach for LLS.

Surgical techniques for liver resection have improved dramatically during the past two decades, and mortality rates for patients undergoing the procedures in high volume centers have decreased to 0–4% [19–21]. Various studies have demonstrated that postoperative morbidity and mortality for patients undergoing liver resection are closely related to the degree of intraoperative blood loss, the majority of which occurs during transection of the liver

Table I. Surgical outcomes.

Outcomes	LigaSure (*n*=7)	Staple (*n*=7)	*p* value
Blood loss (during transection)	17±3.7 cc	40±16.4	NS
Liver transection time (min)	21.8±5.3	15±4.1	NS
Instrument cost ($)	400±50	720±110	<0.05

NS, not significant.

parenchyma. Several techniques have been employed to decreased intraoperative blood loss during liver resection, including the intermittent Pringle maneuver, but few reports have established the superiority of individual procedures [22]. For example, the cavitational ultrasonic surgical aspirator is the most frequently used tool during liver transection, but a randomized clinical trial comparing ultrasonic with manual clamp transection of the liver showed no difference in blood loss or operation time [16,21].

There has been a growing interest in using new devices that facilitate bloodless transection, obviating the need for inflow occlusion. The most popular devices to facilitate transection include the ultrasonic dissector (CUSA, Tyco Healthcare, Mansfield, MA, USA) using ultrasonic energy, the hydrojet (Hydro-Jet, Erbe, Tubingen, Germany) using a pressurized jet of water, the dissecting sealer (TissueLink, Dover, NH, USA) using radiofrequency energy, VSD, and staple [14–18].

The LigaSure Vessel Sealing System is a novel hemostatic device that can seal blood vessels up to 7 mm in diameter by denaturing collagen and elastin within the vessel wall and in the surrounding connective tissue [17]. Vascular staplers to divide hepatic veins and portal branches during hemihepatectomy are considered an achievement that aids in minimizing blood loss and thereby reduces the need for inflow occlusion. Most recently, an ultrasound-directed transparenchymal application of vascular staplers to selectively divide major intrahepatic blood vessels before the parenchymal phase of liver resection has been shown to minimize blood loss, warm ischemia time, and operative time [14]. However, their use for dissection of liver parenchyma during liver resection is not well established.

In this study, we were able to show the application and safety of both staple and VSD for liver transection in laparoscopic liver resection. Both devices were effective for sealing intrahepatic blood vessels and bile ducts without requiring isolation. The level of blood loss was low and comparable in both groups. The transection time was also comparable in both groups. However, the cost of the staple device was higher compared with LigaSure.

One of the limitations of laparoscopic surgery, specifically as applied to liver surgery, is the difficulty of controlling blood vessels and bile ducts. The ability of the staple device and VSD to effectively seal intraparenchymal blood vessels and bile ducts is a significant technological advancement that increases the feasibility of laparoscopic liver resection.

In conclusion, this study showed that both staples and VSD are effective for liver parenchymal transection during laparoscopic liver resection. However, cost is a major factor in using staples.

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