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TECHNIQUE

Laparoscopic resection of left liver segments using the intrahepatic Glissonian approach

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Abstract
Background Recent advances in laparoscopic techniques have resulted in growing indications for laparoscopic hepatectomy. However, this procedure has not been widely developed, and anatomic segmental liver resection is not currently performed due to difficulty controlling the segmental Glissonian pedicles laparoscopically. This study aimed to report a novel technique for laparoscopic anatomic resection of left liver segments using the intrahepatic Glissonian approach based on small incisions according to anatomic landmarks such as Arantius' and round ligaments.
Methods Nine consecutive patients underwent laparoscopic liver resection using the intrahepatic Glissonian technique from April 2007 to June 2008. Five patients underwent laparoscopic bisegmentectomy 2–3, one laparoscopic left hemihepatectomy, two resections of segment 3, and one resection of segment 4.
Results One patient required a blood transfusion. The mean operation time was 180 min (range, 120–300 min), and the median hospital stay was 3 days (range, 1–5 days). No patient had postoperative signs of liver failure or bile leakage. No postoperative mortality was observed.
Conclusion The main advantage of the intrahepatic Glissonian procedure over other techniques is the possibility of gaining a rapid and precise access to the left Glissonian sheaths facilitating left hemihepatectomy, bisegmentectomy 2–3, and individual resections of segments 2, 3, and 4. The authors believe that the intrahepatic Glissonian technique facilitates laparoscopic liver resection and may increase the development of segment-based laparoscopic liver resection.

Keywords Anatomy · Glissonian · Intrahepatic · Laparoscopy · Left · Liver

Recent advances in laparoscopic devices and experience with advanced techniques have increased the indications for laparoscopic liver resection [1, 2]. Although laparoscopic liver resections are considered to be technically demanding and potentially hazardous procedures, several authors have described a growing number of procedures [2–5].

One of the main steps in liver resection is pedicle control. Anatomic hemihepatectomy requires extensive hilar dissection with portal vein and hepatic artery control, whereas segmental resections often are performed without pedicle control or with a selective Pringle maneuver [6]. The indications for laparoscopic segmental liver resection are increasing, but most reported laparoscopic liver resections are hemihepatectomies or nonanatomic resections of liver segments. The intrahepatic Glissonian approach is useful for laparoscopic right hemihepatectomy and segmental liver resection [7–9].

We have previously described a technique for performing resection of left liver segments, including left hepatectomy (resection of segments 2, 3, and 4), bisegmentectomy 2-3, and anatomic resection of segments 2, 3, and 4 using small liver incisions according to anatomic landmarks such as the Arantius' and round ligaments [10]. Using the same concept, this report describes a novel technique for laparoscopic resection of left liver segments using an intrahepatic Glissonian approach.

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Patients and methods

Nine consecutive patients (7 women and 2 men) underwent laparoscopic left liver resection using the intrahepatic Glissonian technique from April 2007 to June 2008. The mean age of these patients was 41.9 years (range, 27–64 years). Five patients had liver metastasis. Three patients had hepatocellular adenoma with a mean size of 11.6 cm (range, 7–19 cm), and one patient had primary intrahepatic lithiasis.

The surgical procedure, postoperative course, and outpatient follow-up observations were evaluated, and the following data were collected prospectively: duration of surgery, average time to control of inflow pedicles, perioperative transfusions, postoperative complications, and hospital stay. The interval timing for control of the portal pedicles was defined by the time from the intrahepatic dissection of the Glissonian sheaths to the establishment of ischemic delineation.

Operative technique

The patient is placed in supine position with the surgeon standing between the patient's legs. An orogastric tube is inserted, then removed at completion of the procedure. This technique requires five trocars. Using an open technique, a 12-mm trocar is placed 3 cm above the umbilicus. Through this port, a 10-mm 30° angled laparoscope is introduced. Pneumoperitoneum is established at a pressure of 12 mmHg. The other four trocars are located as shown in Fig. 1.

The round ligament is transected using laparoscopic coagulation shears (Ethicon Endo Surgery Industries, Cincinnati, OH, USA). Exploration of the abdominal cavity and ultrasound liver examination are performed.

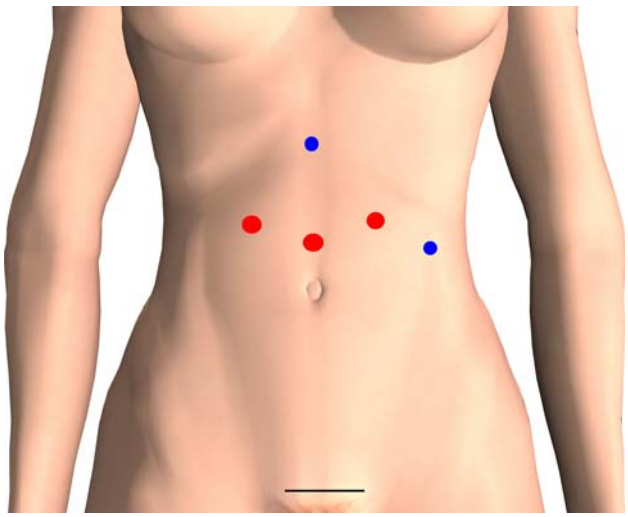

Fig. 1 Diagrams of trocar placement for laparoscopic left liver resection. Three 12-mm trocars (*red*) and two 5-mm trocars (*blue*) are used

The left liver is mobilized by sectioning of the falciform as well as the left triangular and coronary ligaments. The left lobe is pulled upward, and the lesser omentum is divided, exposing the Arantius' ligament (*ligamentum venosum*). This ligament runs from the left branch of the portal vein to the left hepatic vein or to the common trunk [11]. It is a useful anatomic landmark for identification of the left hepatic and portal veins.

The Arantius' ligament is divided. The cephalad stump can be used as a landmark for dissection of the left hepatic vein and the common trunk, as described elsewhere [12]. The caudal stump of the ligament is used as a landmark for the left Glissonian pedicle (shown at A in Fig. 2A). A small (3 mm) anterior incision is made in front of the hilum (shown at B in Fig. 2A), and a large vascular clamp is introduced through the left side of the left Glissonian sheath behind the caudal stump of the Arantius' ligament

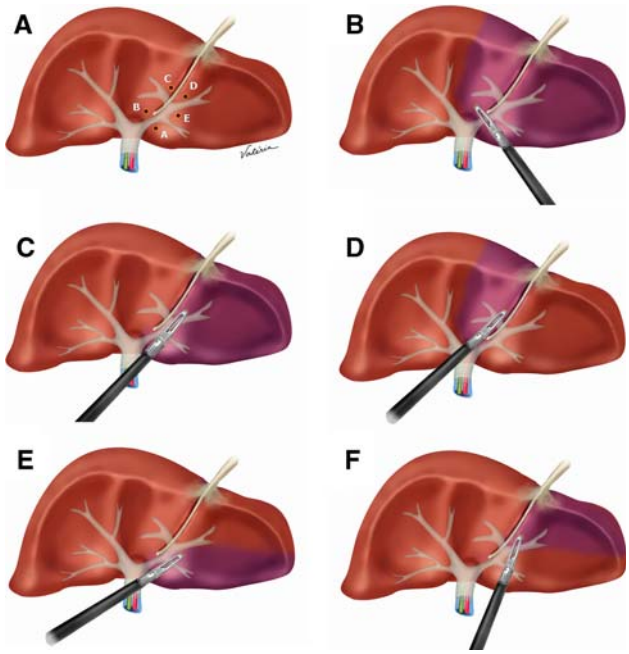

Fig. 2 Schematic view of intrahepatic Glissonian access for laparoscopic left liver resection. (**A**) Landmarks for access of the left liver Glissonian pedicle (including pedicles from segments 2, 3, and 4). Site A indicates the caudal stump of the Arantius' ligament. Site B, indicates the anterior incision in front of the hilum. Site C indicates the basis of the round ligament, right side. Site D indicates the basis of the round ligament, left side. Site E is midway between sites D and A. (**B**) Left hemihepatectomy. A large laparoscopic vascular clamp is introduced through incisions A and B to occlude the left Glissonian pedicle. (**C**) Bisegmentectomy 2–3. Combining incisions A and D, it is possible to occlude the Glissonian pedicle of segments 2 and 3. (**D**) Segmentectomy 4. Combining incisions B and C and using the same maneuver, it is possible to occlude the Glissonian pedicle of segment 4. (**E**) Segmentectomy 2. Combining incisions A and E and using the same maneuver, it is possible to occlude the Glissonian pedicle of segment 2. (**F**) Segmentectomy 3. Combining incisions E and D and using the same maneuver, it is possible to occlude the Glissonian pedicle of segment 3

toward the anterior incision. This allows encircling of the left main sheath (Fig. 2B), which can be divided easily with an endoscopic vascular stapler during a left hemihepatectomy (Fig. 3). This maneuver spares the caudate lobe (segment 1) portal branches.

Next, the round ligament is retracted upward, exposing the umbilical fissure between segments 3 and 4. In about one-third of the patients, a parenchymal bridge connecting these two segments is present and must be divided. Using the round ligament as a guide, two small incisions (C and D in Fig. 2A) are made on the left and right margins of the round ligament, where it is possible to identify the anterior aspect of the Glissonian pedicle of segment 4 on its right side and segment 3 on its left side. By combining incisions A and D (Fig. 2C), it is possible to control the Glissonian pedicle of the left lateral sector (segments 2 and 3). With a clamp introduced through incisions B and C, it is possible to reach the Glissonian pedicle of segment 4 (Fig. 2D). Another small incision can be made midway between incisions A and D (E in Fig. 2A), permitting individual access to either segment 2 or 3 (Fig. 2E and F), allowing individual resections of segments 2 and 3 (Fig. 4).

All these steps are performed without the Pringle maneuver and without hand assistance. The left hepatic vein (Fig. 5) or the common trunk can be dissected and encircled following anatomic landmarks described elsewhere [11, 12].

Parenchymal transection and vascular control of the hepatic veins are accomplished with the harmonic scalpel and the endoscopic stapling device as appropriate. The specimen is extracted through a suprapubic incision inside a plastic bag. One round 19F Blake abdominal drain (Ethicon, Inc, Cincinnati, OH, USA) is left in place in all patients.

Results

Five patients underwent laparoscopic bisegmentectomy 2–3, one laparoscopic left hemihepatectomy (Fig. 3), two resections of segment 3, and one resection of segment 4. Blood transfusion was required for one patient. The mean time needed to achieve complete control of the pedicles was 4.7 min (range, 2–16 min), and the mean operative time was 180 min (range, 120–300 min). The median hospital stay was 3 days (range, 1–5 days). No patient had postoperative signs of liver failure or bile leakage, and no postoperative mortality was observed.

Four patients underwent surgery for benign primary tumor, whereas the remaining five patients had surgery for malignant secondary tumors. These five patients had a negative surgical margin larger than 1 cm. One patient exhibited moderate postchemotherapy steatohepatitis, and two patients had mild steatosis. Intraoperative laparoscopic liver ultrasound confirmed the site and size of the lesions diagnosed by CT scan, magnetic resonance imaging (MRI), or both.

Discussion

Knowledge of the segmental liver anatomy, as described by Couinaud [10], has provided the basis for segmental liver resection. The liver can be divided into eight different

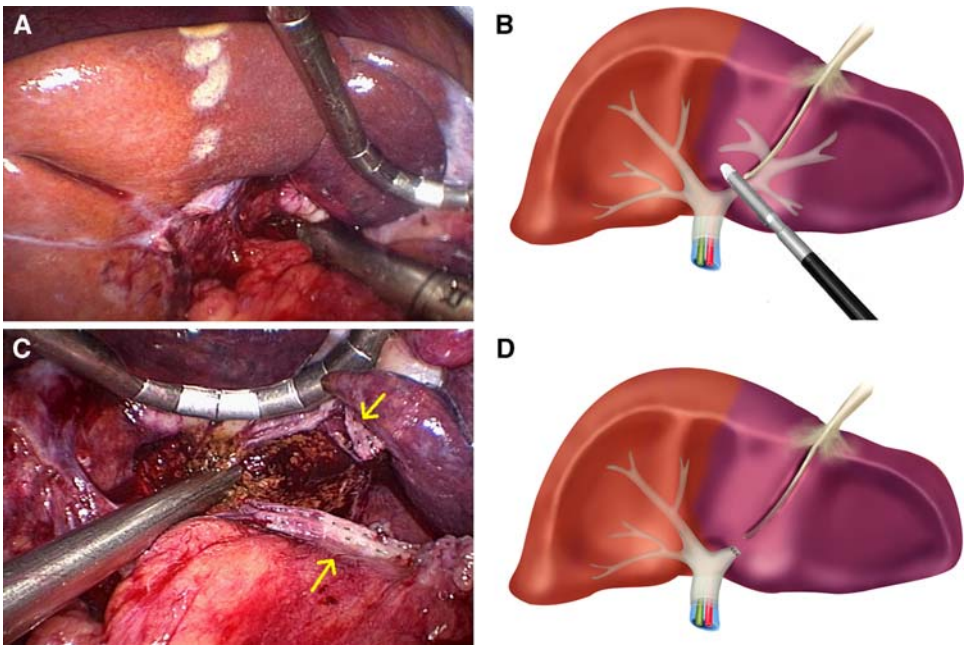

Fig. 3 Laparoscopic left hemihepatectomy (resection of segments 2, 3, and 4). (**A**) Intraoperative view showing ischemic delineation of the left liver. Note the vascular endoscopic stapler encircling the left Glissonian pedicle. (**B**) Schematic view. The stapler is closed, and ischemic delineation of the left liver is obtained. (**C**) Intraoperative view. The stapler is fired, and the left main Glissonian pedicle is transected (*arrows*). (**D**) Schematic view. The stapler is fired

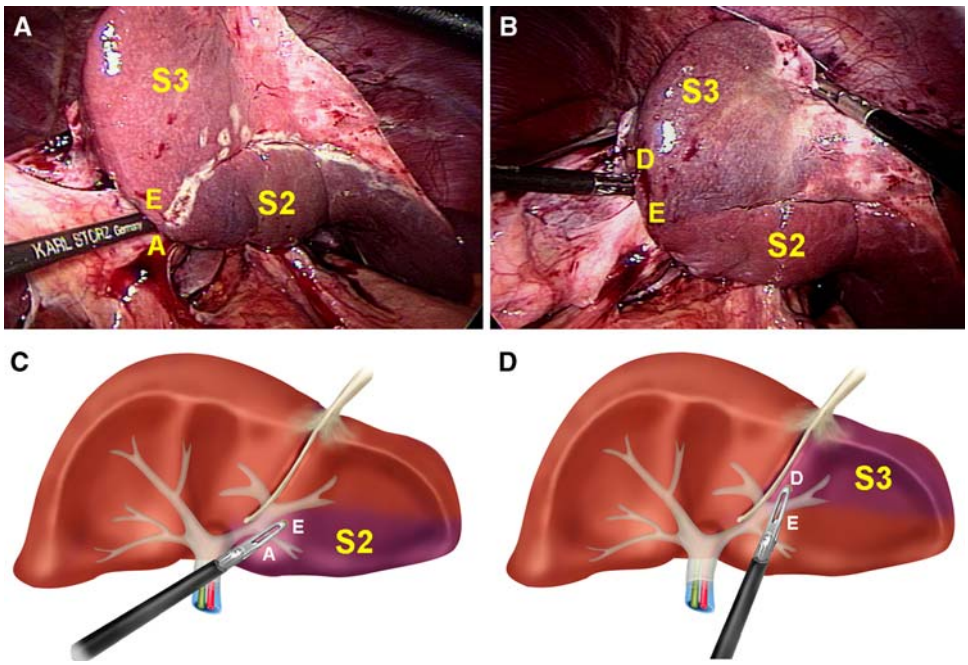

Fig. 4 Laparoscopic anatomic resection of segments 2 and 3. (**A**) Intraoperative photograph. The Glissonian pedicle is occluded, and ischemic delineation of segment 2 (S2) is obtained. Segment 3 is not ischemic (S3). (**B**) Intraoperative photograph. The Glissonian pedicle is occluded, and ischemic delineation of segment 3 (S3) is obtained. Segment 2 is not ischemic (S2). (**C**) Schematic view. A large laparoscopic vascular clamp is introduced through incisions A and E, resulting in ischemic delineation of segment 2 (S2). (**D**) Schematic view. A large laparoscopic vascular clamp is introduced through incisions E and D, resulting in ischemic delineation of segment 3 (S3)

segments: segment 1 as the caudate lobe; segments 2, 3, and 4 as the left liver, and segments 5, 6, 7, and 8 as the right liver.

The main indication for the segmental approach is to preserve the liver parenchyma, especially in cases with bilateral lesions or cirrhotic livers. This approach permits complete anatomic clearance of the disease, leaving an adequately functioning liver, by removal of individual hepatic segments.

Removal of anatomic liver segments by laparoscopy is a difficult task. Indeed, most laparoscopic liver procedures are right or left hemihepatectomies, left lateral segmentectomies, and nonanatomic liver resections [3]. Anatomic segmental liver resection is not currently performed due to technical difficulties controlling segmental Glissonian pedicles laparoscopically. The authors have previously reported a technique for laparoscopic right segmental liver resection [10]. Based on this experience, they describe a systematized technique for reaching the left Glissonian pedicles and removing any left liver segments by laparoscopy. These techniques permit a tailored liver resection by removal of only the liver segments involved in the underlying disease. Respect for anatomic landmarks of liver segments during resection prevents impairment to the vascularization of the remaining parenchyma and excessive bleeding.

The Pringle maneuver, a main step during laparoscopic liver resection, is used to avoid major bleeding but can be associated with prolonged ischemic time. Laurent et al. [13] showed that laparoscopic liver resection is associated with higher ischemic time. The current technique precludes the use of the Pringle maneuver and permits not only hemihepatectomy but also segmental liver resection.

Outflow control is of utmost importance during liver resection and can be accomplished when necessary (Fig. 5). Anatomic landmarks described elsewhere can be used to guide the laparoscopic surgeon to a safe dissection of both the left and middle hepatic veins (Fig. 5).

This novel technique can expand the indication for laparoscopic segment-based liver resection, sparing the liver parenchyma. Preservation of the liver parenchyma should always be attempted to prevent postoperative liver failure and to increase the opportunity to perform repeated resections in cases of recurrent malignancy [14].

Left hemihepatectomy can be achieved with dissection of the left hepatic artery, duct, and portal vein separately [2–5], which is tedious and time consuming. It also may jeopardize vascular and biliary vessels if anatomic variation is present. The current technique, based on small incisions following specific anatomic landmarks, allows a straightforward control of the Glissonian pedicle (Fig. 3) without hilar or parenchymal dissection and without ultrasound or cholangiography guidance. This technique precludes encircling of the Glissonian pedicles, thus simplifying the procedure and minimizing bleeding from this blunt maneuver, which is much more difficult to perform laparoscopically.

The main advantage of this technique over others is the possibility of gaining a rapid and precise access to every Glissonian sheath of segments 2, 3, and 4, facilitating left hemihepatectomy, bisegmentectomy 2-3, and resection of liver segments 2, 3, and 4.

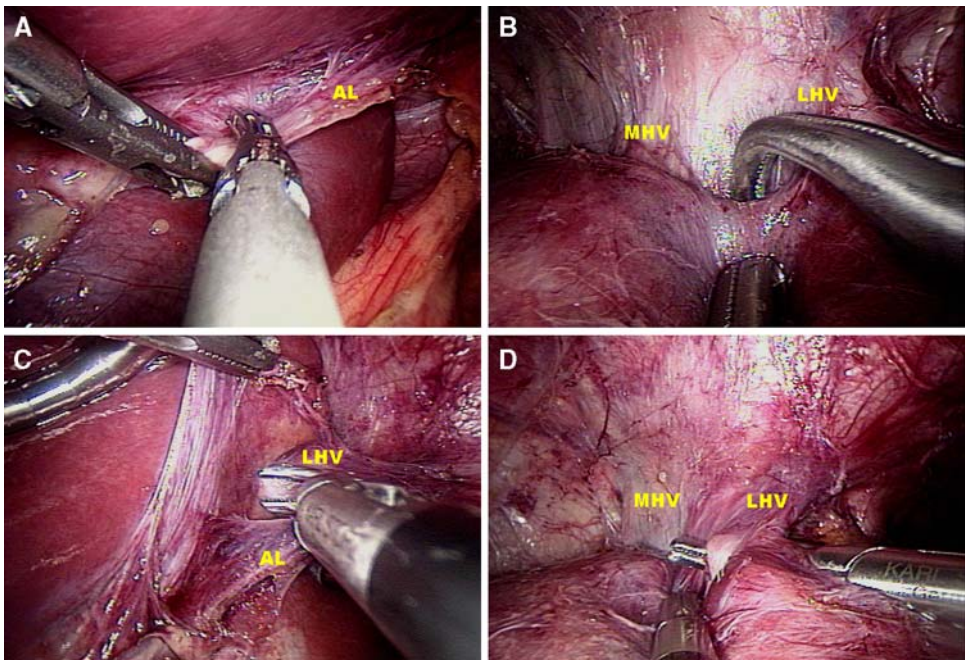

Fig. 5 Intraoperative view showing laparoscopic dissection of the left hepatic vein. (**A**) Arantius' ligament (AL) is divided. (**B**) Dissection between the middle (MHV) and the left hepatic vein (LHV) is accomplished with a laparoscopic right angle dissector. (**C**) The cephalad stump of Arantius' ligament (AL) can be used as a landmark to dissect the LHV. (**D**) The LHV is encircled by the right angle dissector. The MHV is not included in the dissection

We believe that the described technique facilitates laparoscopic liver resection by reducing the technical difficulties in pedicle control and may increase the development of segment-based laparoscopic liver resection.

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