



Technical tips concerning laparoscopic hepaticojejunostomy for choledochal cyst in children with a focus on secure anastomosis for small hepatic ducts

Satoshi Ieiri, Masakazu Murakami, Tokuro Baba, Toshio Harumatsu, Koji Yamada

Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University, Kagoshima City, Japan

Correspondence to: Satoshi Ieiri, MD, PhD, FACS. Department of Pediatric Surgery, Research Field in Medical and Health Sciences, Medical and Dental Area, Research and Education Assembly, Kagoshima University, 8-35-1, Sakuragaoka, Kagoshima City 890-8520, Japan. Email: sieiri@m.kufin.kagoshima-u.ac.jp.

Abstract: Laparoscopic hepaticojejunostomy for choledochal cyst in children is one of the most technically challenging operative procedures. Recent advances in high-definition imaging modalities have brought a better intraperitoneal visibility and expanded the indication to meticulous anastomosis for small bile ducts. In our standardized method, the hepatic duct is resected at the common hepatic duct level above the cyst. The jejunum is then extracted from an umbilical wound, and Roux-en-Y jejunostomy is performed. The small hepatic duct is enlarged using a diagonal cut up the left side of the hepatic duct (in the 3 o'clock direction). Anastomotic hole is made at anterior wall of jejunum based on the size of hepatic duct. The mucosa and serosa of the opened hole is approximated using 6-0 monofilament absorbable sutures in order to perform membrane-to-membrane anastomosis. After stay sutures are laid, the posterior wall is sutured using interrupted 6-0 absorbable monofilament intracorporeal knot tying. Anastomosis is completely performed without stent insertion. During the anastomotic steps, the suspension technique for the anterior wall of the hepatic duct is very useful for confirming the lumen of the hepatic duct. However, this approach is associated with several well-known intraoperative pitfalls, such as the involvement of posterior wall needle-driving during anterior wall anastomosis, so the surgical team should be alert to prevent such events.

Keywords: Choledochal cyst; children; hepaticojejunostomy; small hepatic duct; duct plasty

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Introduction

Laparoscopic hepaticojejunostomy for choledochal cyst was first performed for adult patients in the late 1990s (1). Initially, cyst excision was performed laparoscopically, while hepaticojejunostomy was performed under direct vision through small laparotomy (2). Recently, all procedures, including cyst excision, Roux-Y anastomosis, and hepaticojejunostomy, in adult cases have come to be performed completely laparoscopically (3).

Laparoscopic surgery for choledochal cyst in children is also feasible, and many cases have been performed in Asian countries (4,5). In addition, single-incision

laparoscopic surgery for choledochal cyst in small children has also been reported (6,7). In small infants, the organs are fragile and easily bleed, but dissection is not difficult because of the good visibility due to the small amount of fat tissue in abdominal cavity. However, laparoscopic hepaticojejunostomy for small hepatic ducts in children remains one of the most technically challenging aspects of such procedures. Pediatric surgeons require advanced needle-driving and suturing skills and must sometimes perform duct plasty for secure anastomosis (8,9).

We herein report a standardized procedure in our institution for performing laparoscopic hepaticojejunostomy

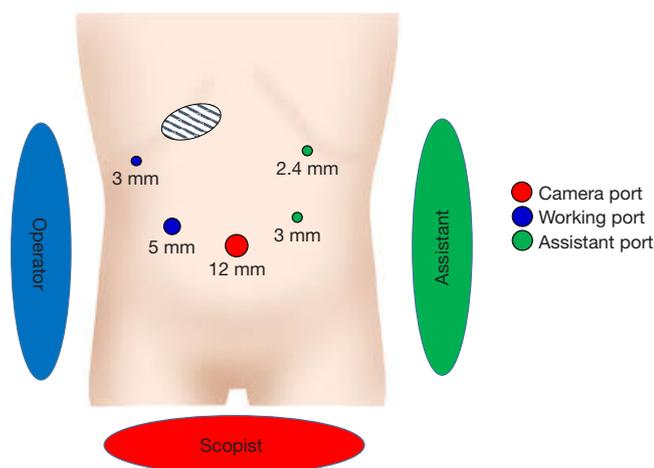


Figure 1 Port placement and surgeon's position.

for small hepatic ducts in children.

Patient selection and workup

Using preoperative imaging modalities, such as enhanced computed tomography (CT), magnetic resonance cholangiopancreatography (MRCP) and drip infusion cholecysto-cholangiography-CT (DIC-CT), the type of common bile duct dilatation, type of pancreaticobiliary maljunction, length of common channel, presence or absence of protein plague, and variation of the right hepatic artery (positional relationship of hepatic duct) should be confirmed preoperatively. Regarding the timing for definitive operation, antenatal diagnosed cases should undergo the procedure electively at least three months after birth. However, a radical operation is technically feasible for patients over 3 kg in body weight (10).

Surgical position and port layout

Under general anesthesia, older pediatric patients are placed in a broad base position. Small infants are placed in a supine position caudally on the operative bed so the operator can stand and manipulate the forceps at the end of the operation table. Our standard port placement is shown in *Figure 1*.

The umbilicus is opened through a 1.5-cm longitudinal incision, and a wound retractor (LAP PROTECTOR; Mini-mini; Hakko, Co., Ltd., Tokyo, Japan) is applied. A 5- or 10-mm 30° or 45° laparoscope is inserted through a special silicone cap (E · Z access for FF0504; Hakko, Co., Ltd.) to attach to the wound retractor. We routinely use

a 10-mm rigid high-definition endoscope (KARLSTOZ, Tuttlingen, Germany). In most of the operative steps, the operator stands at the right side of the patient, except for during dissection of huge adhesive cysts. The assistant surgeon stands on the opposite side, and the camera assistant stands between the patient's legs.

Pneumoperitoneum is established by CO₂ insufflation at 8 mmHg. The CO₂ flow is determined based on the patients' size. Three additional trocars are inserted: one each at the right upper abdomen (3 mm, operator's left hand), right side of the umbilicus (5 mm, operator's right hand), and left lateral abdomen (3 mm, assistant's left hand). A 2.4-mm percutaneous needle-type grasper (MiniLap®; Teleflex, Morrisville, NC, USA) is inserted at the left upper abdomen for gallbladder retraction, as shown in *Figure 1*.

The round ligament of the liver is elevated using 2-0 silk sutures through 19-G percutaneous needle ligature carrier insertion (LAPA-HER-CLOSURE, Hakko, Co., Ltd.) to provide vision of the inferior space of the liver. In general, the tissue around the lesion is likely to be wet or sometimes firm due to inflammation related to repeated cholangitis. Oozing hemorrhaging from the cyst wall in particular tends to hamper precise dissection. During the operative procedure, a suction device is also frequently used to suck out any superfluous discharge. Specialized small gauze for endoscopic surgery (TROX™; Type D; Oosaki Medical, Nagoya, Japan) must be used for gentle suction. In this manner, a dry operative field can be maintained.

In cases of non-dilated pancreaticobiliary maljunction, the bile is sampled directly through percutaneous needle puncture, and the amylase level in the bile is measured. The amylase value will then determine whether hepaticojejunostomy or simple cholecystectomy should be performed.

Cyst dissection and excision

To obtain a sufficiently clear view of the hepatic portal region, the fundus of gallbladder is grasped with a percutaneous needle-type grasper (MiniLap®; Teleflex) and elevated toward the cranial direction. Using energy devices, such as a vessel sealing system (LigaSure™ Maryland; Medtronic plc, Minneapolis, MN, USA), a 3-mm Vessel sealer (JustRight™ 3-mm Vessel Sealing System; JustRight Surgical, LLC., Louisville, CO, USA), and an ultrasonically activated device (HARMONIC® HD 1000i Shears; Johnson & Johnson, New Brunswick, NJ, USA), along with 3.5-mm bipolar forceps (RoBi; KARLSTORZ), the cyst

wall is carefully dissected. In cases of huge choledochal cyst, the bile is aspirated to obtain a posterior view of the cyst before dissection. Dissection of the posterior wall of the cyst is completely performed, and the cyst is taped. After taping of the cyst wall, the distal side of the cyst inside the pancreatic tissue is dissected. The pancreatic tissue is dissected around the cyst using sharp dissection. A metal clip (LIGAMAX5[®]; Johnson & Johnson) is applied at the distal side of the cyst as a landmark of transection.

Intraoperative cholangiography

The fundus of the gallbladder is dissected, and a catheter is inserted through the right upper 3-mm trocar or via the additional insertion of a 2-mm trocar (Mini Port; Medtronic plc). A catheter (CHOLANGIO-CATHETER; Hakko, Co., Ltd.) is ligated using an endoloop (ENDOLOOP[®] Ligature; Johnson & Johnson), and intraoperative cholangiography is performed. After measuring the distance between the landmark metal clip and the joint portion of the bile duct and pancreatic duct, additional dissection is performed as needed. The distal side of cyst is ligated just above the joint portion using 4-0 or 5-0 monofilament transfixing sutures (PDS[®] Plus; Johnson & Johnson), and a polymer clip (Weck[®] Hem-o-lok[®] Polymer Ligation System-Automatic; Teleflex) is additionally applied.

After transection of the distal side of the choledochal cyst, the posterior wall of the cyst is carefully dissected from the portal vein.

Preparation of the jejunal limb and Roux-en-Y anastomosis

Before performing Roux-en-Y anastomosis, the jejunum 30 cm distal from the ligament of Treitz is marked with crystal violet and grasped with forceps by the assistant surgeon under a laparoscopic view in order to maintain confirmation of the peristaltic direction. After the marked jejunum is grasped and the silicone cap detached (E-Z access for FF0504; Hakko, Co., Ltd.), the grasped jejunum is extracted through the wound retractor.

After verifying the vessels' structure in the mesentery, the jejunum is divided using a linear stapler, usually approximately 30 cm distal from the ligament of Treitz. The marginal vessel is divided. If there is still strong tension so far, a branch of the jejunal artery and vein is divided after a clamping test using a temporary vessel clasper. The length of the jejunal limb is determined based on

the patient's body size (approximately 30–40 cm). Jejunojejunostomy is performed in a side-to-side fashion using a 35-mm linear stapler (Powered ECHELON FLEX[®]; Johnson & Johnson) or 25-mm linear stapler (JustRight[™] 5-mm Stapler; JustRight Surgical, LLC), and the entry hole is closed by hand-sewing in the full-thickness layer using 5-0 monofilament sutures (PDS[®] Plus; Johnson & Johnson). The mesentery gap that results from the jejunojejunostomy is also closed by hand-sewing.

Finally, a small anastomotic hole for the subsequent hepaticojejunostomy is made at the end of the jejunal limb. The size of the anastomotic hole is determined based on the size of the hepatic duct. The anastomotic hole is positioned not just at the anti-mesenteric side but also slightly anterior on the abdominal side to ensure good visualization during hepaticojejunostomy. After making the anastomotic hole, the mucosa and the serosa are approximate using 6-0 monofilament (PDS[®] Plus; Johnson & Johnson) interrupted sutures. This procedure is important for performing membrane-to-membrane hepaticojejunostomy of a small hepatic duct. Because deciding on the position for Roux-en-Y anastomosis under laparoscopy can be difficult in infants and small children, it is routinely done under direct vision while measuring the distance accurately and stretching the intestine outside of the abdominal wall.

Duct-plasty and hepaticojejunostomy

There is a risk of anastomotic stricture after hepaticojejunostomy in patients with a small hepatic duct. In our standardized method, the hepatic duct is resected at the common hepatic duct level above the cyst (*Figure 2A*). The small hepatic duct is enlarged using a diagonal cut up the left side of the hepatic duct (in the 3 o'clock direction) (*Figure 2B,C*). We do not cut the right side of the hepatic duct in order to avoid injuring the posterior branch. For the cutting device, we use fine scissors (Mini Endocut; Microline Surgical, Beverly, MA, USA). Hemostasis at the cutting edge of the hepatic duct is minimum in order to prevent thermal injury of the hepatic duct. At the start of hepaticojejunostomy, we usually lay down stay sutures at the left side of the hepatic duct (in the 3 o'clock direction). After stay suture using 5-0 monofilament (PDS[®] Plus; Johnson & Johnson) intracorporeal knot tying is made at left side of hepatic duct, the long tail of the suture is suspended by the needle device (LAPA-HER-CLOSURE, Hakko, Co., Ltd.) insertion at the left upper abdomen (*Figure 3A*). After stay sutures are laid, the posterior wall

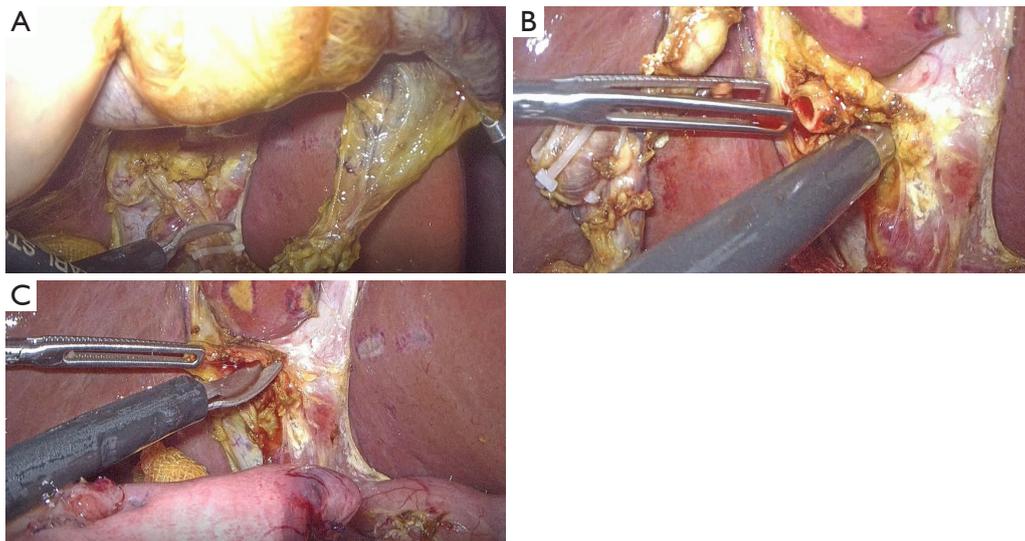


Figure 2 Enlargement and duct-plasty for small hepatic ducts. (A) Cutting the hepatic duct just above the cyst; (B) small hepatic duct, approximately 3–4 mm in size; (C) making a diagonal cut up the left side of the hepatic duct.

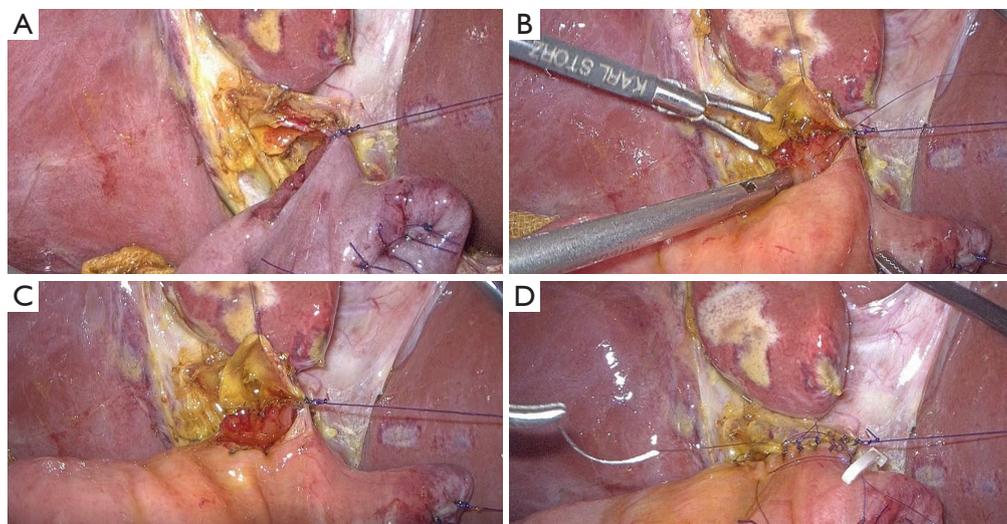


Figure 3 Technique for meticulous hepaticojejunostomy. (A) Stay sutures laid at the left side of the hepatic duct; (B) anastomosis of the posterior wall using interrupted 6-0 monofilament sutures; (C) suspending technique for the anterior wall of the hepatic duct; (D) only needle-driving performed before finishing the anastomosis.

is sutured using interrupted 6-0 absorbable monofilament (PDS[®] Plus; Johnson & Johnson) intracorporeal knot tying (*Figure 3B*). In order to obtain stable visualization and perform secure membrane-to-membrane anastomosis, the anterior wall of the hepatic duct is also suspended using 5-0 absorbable monofilament (PDS[®] Plus; Johnson & Johnson) from outside of the body (*Figure 3C*). After finishing the posterior wall anastomosis, the anterior wall

is sutured as same fashion of 6-0 monofilament (PDS[®] Plus; Johnson & Johnson) intracorporeal knot tying. The suspending sutures is removed after half of the anterior wall of the anastomosis is finished. Before finishing the anterior wall of anastomosis, only needle-driving is performed for the final three sutures (*Figure 3D*). And then knot tying is performed to finish the hepaticojejunostomy. This technique helps avoid the risk of the involvement of posterior wall

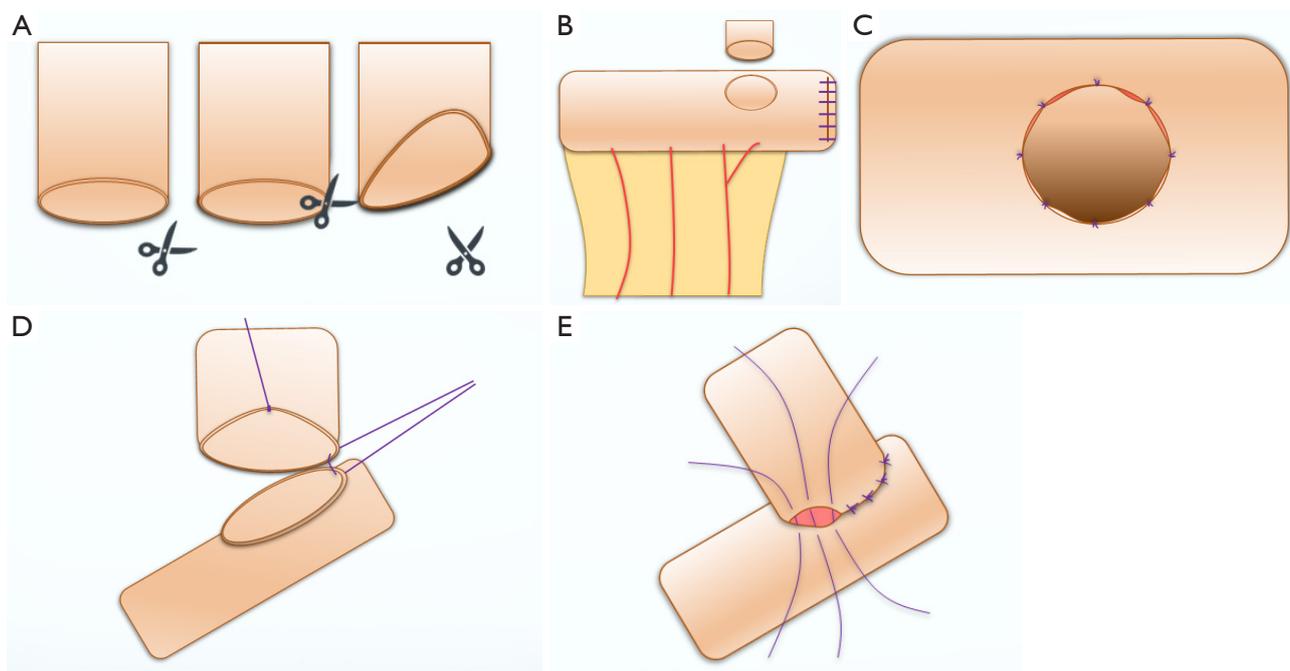


Figure 4 Schematic illustration of potential pitfall points. (A) Diagonal cut up the left side of the hepatic duct; (B) anastomotic hole of the jejunum; (C) approximating the mucosa and serosa of the jejunal anastomotic hole; (D) stay sutures at the left side of the hepatic duct; suspending technique for the anterior wall of the hepatic duct; (E) only needle-driving performed before finishing the anastomosis.

needle-driving during anterior wall anastomosis because of confirming the lumen of the hepatic duct and mucosal layer of the anastomotic hole of jejunum. Anastomosis is completely performed without stent insertion.

Post-operative management

A 10- or 15-Fr closed-type drainage tube with continuous aspiration is placed behind the hepaticojejunostomy. The amylase levels of the discharge in the tube are measured on the 1st and 3rd postoperative days. If no abnormal elevation of the amylase levels or cloudiness is noted in the discharge, the tube is removed on the 4th postoperative day. Drinking water is started on the 3rd or 4th postoperative day, and soft meals are started on the 5th postoperative day. Patients are discharged from the hospital on the 7th–9th postoperative day if no complications are noted.

Pitfalls and strategies for managing difficult situations

Duct plasty and confirmation of the lumen for anastomosis are important points associated with pitfalls in

hepaticojejunostomy of small hepatic ducts in children. Our cutting method and anastomotic procedure are effective and useful for performing hepaticojejunostomy, even for surgeons in training (*Figure 4*). However, pediatric surgeons must endeavor to acquire precise needle-driving and stable knot-tying techniques.

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Footnote

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