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Viewpoint

Laparoscopic approach for choledochojejunostomy

Tomohide Hori[a,*], Yuki Aisu[b], Michihiro Yamamoto[a], Daiki Yasukawa[b], Taku Iida[c], Shintaro Yagi[c], Kentaro Taniguchi[d], Shinji Uemoto[c]

[a] Department of Surgery, Shiga General Hospital, Moriyama 524-8524, Japan
[b] Department of Digestive Surgery, Tenriyorodusoudanjyo Hospital, Tenri 632-8552, Japan
[c] Department of Hepato-Biliary-Pancreatic and Surgery and Transplantation, Kyoto University Hospital, Kyoto 606-8507, Japan
[d] First Department of Surgery, Mie University Hospital, Tsu 514-8507, Japan

Laparoscopic hepatobiliary and pancreatic (HBP) surgery has been developed slowly because of technical challenges and a protracted learning curve with the exception of laparoscopic cholecystectomy [1]. Surgical treatments for benign diseases of the extrahepatic bile duct (EHBD) are classified according to their therapeutic purpose as lithotomy (i.e., choledocholithotomy) or diversion (i.e., choledochojejunostomy) [2]. General surgeons do not perform these surgeries laparoscopically because they require advanced skills and anatomical precision [3,4]. The basic skills required for laparotomy are clearly different from those used in laparoscopic procedures. Notably, experience alone is not enough to ensure successful performance of laparoscopic surgeries [1].

We herein focus on laparoscopic choledochojejunostomy, summarizing tips and pitfalls, on the basis of a review of important studies and our own experience. We hope that our article with visual explanation and literature review will be informative for skillful HBP surgeons.

Pancreaticobiliary maljunction (PBM): PBM is a congenital malformation in which the pancreatic and bile ducts join outside the duodenal wall and generally form a long common channel [5–8]. Definitive diagnosis of PBM is made with imaging studies, which show evidence of an extramural union of the pancreatic and bile ducts and the existence of an abnormally long common channel [5–8]. Elevated amylase in the bile duct and/or gallbladder supports the diagnosis [7,8]. When the physiologic action and functional regulation of Oddi's sphincter are lost, two-way regurgitation occurs. Reflux of pancreatic juice into the biliary tract causes cholangitis and cholecystitis; chronic inflammation is associated with a high incidence of epithelial changes (e.g., the hyperplasia, dysplasia and carcinoma sequence). Carcinogenesis related to PBM is considered a hyperplasia–dysplasia–carcinoma sequence, which differs from the adenoma–carcinoma sequence or *de novo* carcinogenesis [7,8], and results in biliary and gallbladder cancers [5–8]. At the same time, reflux of bile into the pancreatic duct causes chronic pancreatitis [7,8]. Congenital biliary dilatation is defined as a congenital malformation involving both a local dilatation of the extrahepatic and/or intrahepatic bile ducts and the coexistence of PBM [5,6]. Secondary dilatation of the biliary tract resulting from obstruction due to biliary stones or malignancy should be strictly excluded. Although almost all patients with congenital biliary dilatation have PBM [8], the detailed etiology of congenital biliary dilatation remains unclear. It is currently accepted that no causal association exists between congenital biliary dilatation and PBM based on the fact that congenital biliary dilatation can be present without PBM and the experimental results of intentional injection of pancreatic juice into the biliary duct.

Some PBM patients need surgical treatment [9], with surgical procedures chosen according to the coexistence of congenital biliary dilatation [5,7–9]. Prophylactic resection of the EHBD, cholecystectomy and biliary diversion (i.e., choledochojejunostomy) is the standard surgery for PBM with concurrent congenital biliary dilatation. Complete excision of the intrapancreatic bile duct and removal of narrow segments of the hepatic ducts are necessary but very difficult [5,6]. Direct cholangiography by retrograde endoscopic approach and drip infusion cholangiography with computed tomography are useful for bile duct evaluation [5,6,8]. Even a mild injury to the main pancreatic duct results in intractable postoperative complications [5,7,8]. Detailed evaluation of the pancreatic duct and common channel with cholangiography before and during surgery is very important [5,7,8]. Preoperative placement of a pancreatic drainage tube [5,7,8] or intraoperative cholangiography with a clip marking can help prevent unexpected injury to the main pancreatic duct. Even long after biliary diversion, the postoperative incidence of biliary carcinoma has been documented at a frequency of 0.7%–5.4%. Ongoing follow-up is therefore necessary [5,7,8]. In contrast, cholecystectomy alone is adequate treatment for PBM patients without congenital biliary dilatation [5,6,8]. Prophylactic resection of the EHBD with biliary diversion from the pancreatic duct is unnecessary for PBM patients without bile duct dilatation, when neither bile stasis nor associated cholangitis is observed [5].

Recurrent stones in the bile duct and associated cholangitis: recurrent stones (not remnant stones) in the bile duct after choledocholithotomy or endoscopic sphincterotomy (EST) is another critical matter [2,10,11]. Early stone recurrence after surgical or endoscopic treatment is a dreaded occurrence for physicians [2,10].

* Corresponding author.
E-mail address: horitomo55office@yahoo.co.jp (T. Hori).

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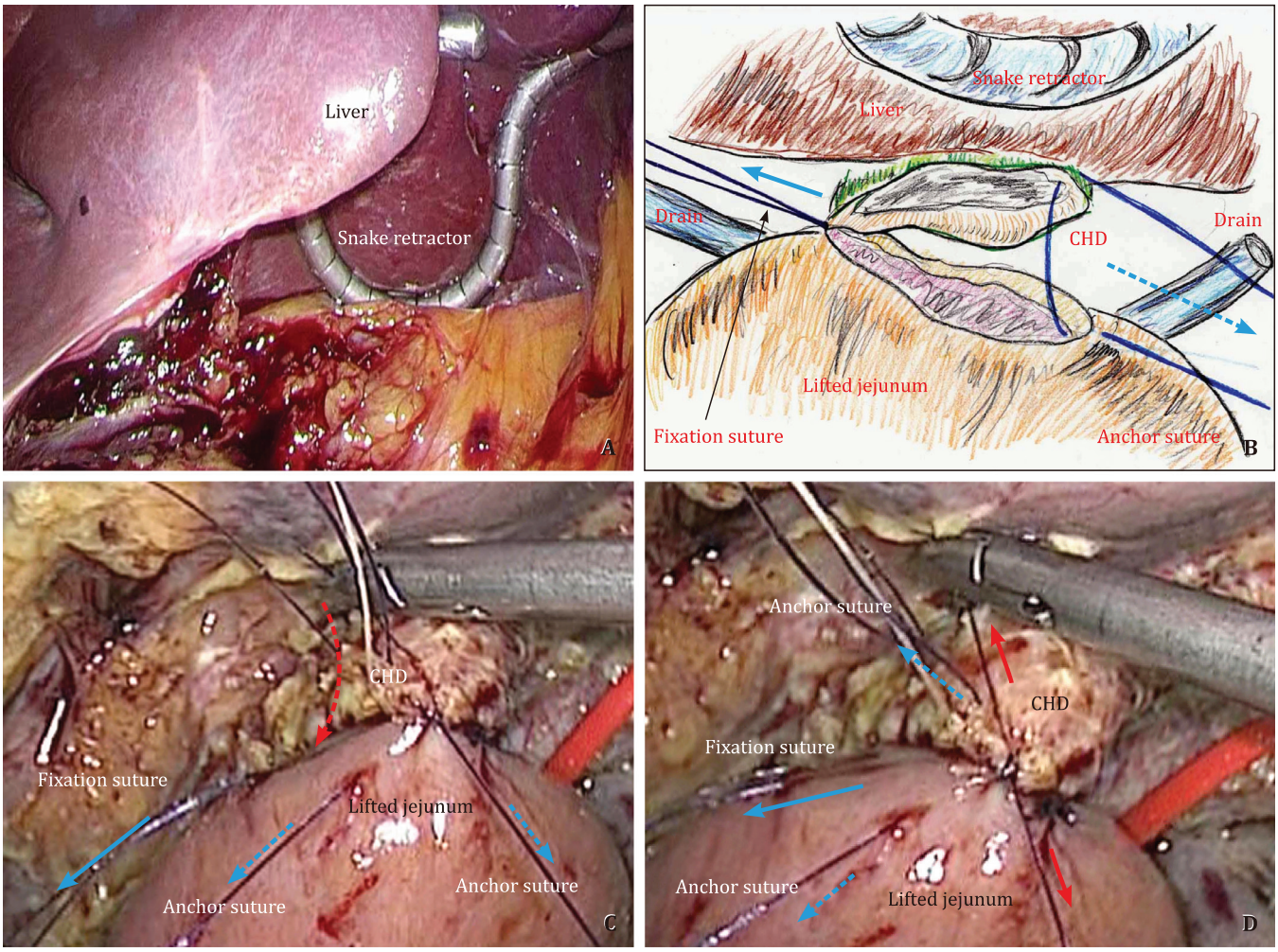

Fig. 1. A: The liver is held cranially with a snake retractor or Nathanson's liver retractor located below the xiphoid process; **B:** A fixation suture (solid blue arrow) is placed on the patient's right side (i.e., on the side opposite the main surgeon). At the edge on the patient's left side (i.e., on the side nearer the main surgeon), an anchor suture without ligation (blue dotted arrow) is placed. The fixation and anchor sutures are adequately set through the abdominal wall. A drain can be placed beforehand; **C** and **D:** Laparoscopy provides an excellent overhead view with adequate magnification and light source. The fixation suture (solid blue arrow) and anchor suture without ligation (blue dotted arrows) help to create the surgical field. Optimal placement of the main surgeon's forceps is advantageous for anastomotic procedures including intracorporeal suturing (**C**, red dotted arrow) and subsequent ligation (**D**, solid red arrows). CHD: common hepatic duct.

Laparoscopic choledocholithotomy provides safe and feasible treatment for recurrent stones and associated cholangitis [12,13]. Physiological disorders (e.g., dysfunction of Oddi's sphincter, reduced bile secretion, atonic gallbladder and paralytic bowels) concern about recurrent stones and associated cholangitis [1,12,14,15]. Elective laparoscopic cholecystectomy after complete removal of bile duct stones does not reduce the recurrence rate of repeat cholangitis. The etiology of bile duct stones should be carefully evaluated and therapeutic strategies should be chosen according to definitive or suggested etiology. Laparoscopic choledochojejunostomy is a possible therapeutic option to provide biliary diversion for physiological disorders [2,6].

The following is the visual explanation for laparoscopic choledochojejunostomy procedures from our experience. Incisions of the bile duct and lifted jejunum are accompanied by outflows of bile and jejunal juice. Saline irrigator and suction tip (StrykeFlow; Stryker Co., Kalamazoo, MI, USA) and an automatically maintained pneumoperitoneum system (AirSeal Intelligent Flow System; Conmed Co., Utica, NY, USA) were used. An excessively narrow or wide angle of laparoscopic forceps complicates laparoscopic procedures, including fully intracorporeal anastomosis [1]. The liver is held cranially with a snake retractor or Nathanson's liver retractor located below the xiphoid process (Fig. 1A). The hepatoduodenal ligament is well stretched [1]. The hepatorenal fossa is widely dilated, and a working space is obtained. The operative time for laparoscopic choledochojejunostomy may be easily estimated, whereas that of laparoscopic choledocholithotomy is extremely influenced by the duration of stone removal. Vessels around the EHBD should be preserved to prevent ductal necrosis and biliary leakage after surgery [1]. Intracorporeal suture placement and subsequent ligation at the bleeding point are the first choice for hemostasis near the bile duct. Jejunojejunostomy of the lifted jejunal limb is extracorporeally performed with hand suturing in layer-to-layer anastomosis. Autonomic nerves in the mesojejunum of the lifted jejunal limb are preserved to maintain physiological peristalsis and to prevent postoperative cholangitis. Lavage and drain placement are usually required at the end of surgery. However, optimal drain placement is difficult after completion of choledochojejunostomy, because even a subtle retraction of the lifted jejunum can cause injury to the anastomosis itself. Hence, a drain is placed before anastomosis (Fig. 1B) and is clamped to avoid air leakage. At the edge on the patient's right side (i.e., on the side opposite the main surgeon), a fixation suture is placed with absorbable monofilament suture (Monocryl 3-0, 90 cm, violet, SH Plus; Ethicon, Inc.,

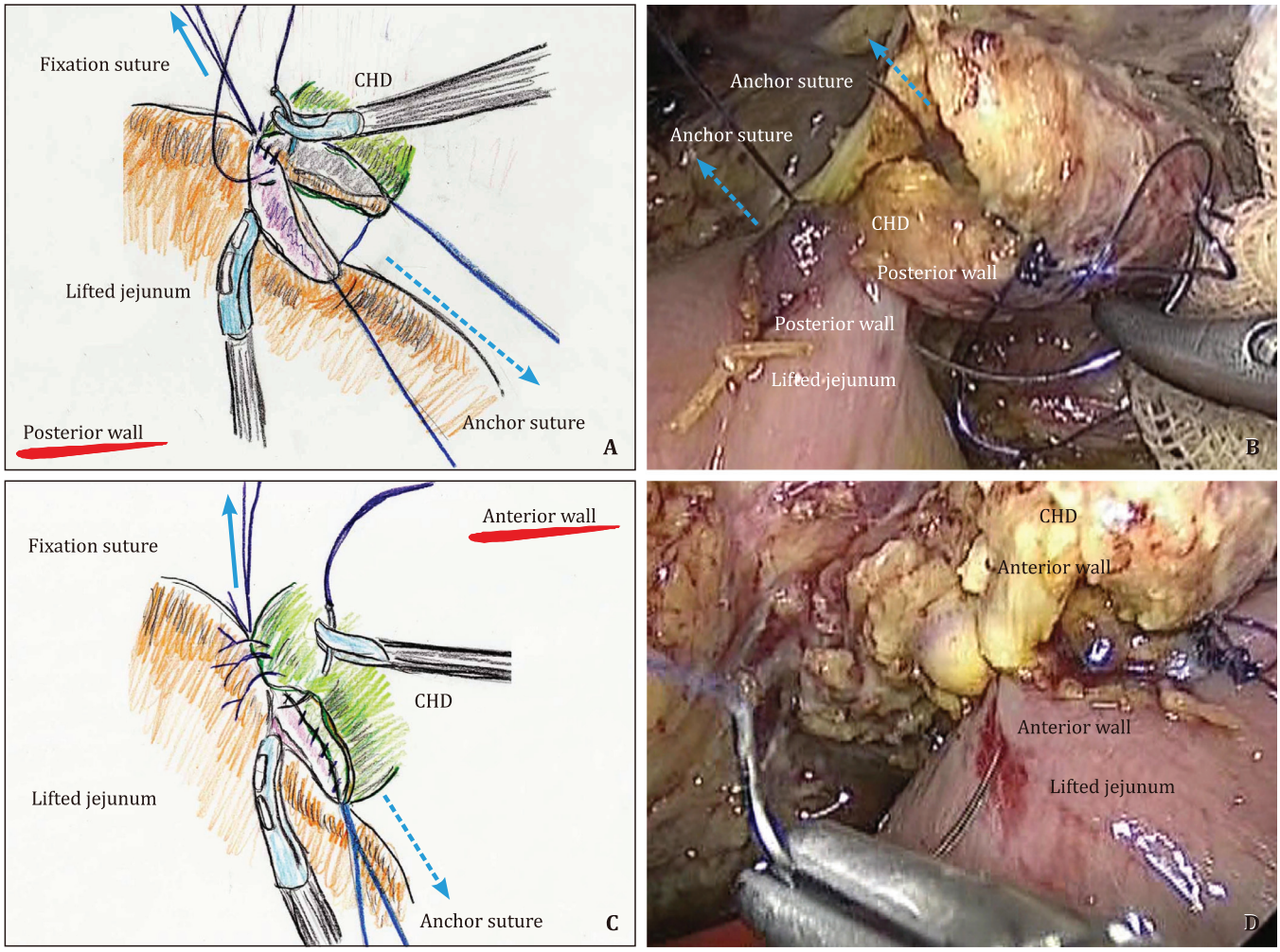

Fig. 2. **A** and **B:** The posterior wall is anastomosed with running or interrupted sutures. Fixation suture (solid blue arrow) and anchor suture without ligation (blue dotted arrow) are placed. Anchor suture without ligation (blue dotted arrows) helps to surely suture the posterior walls of the CHD and lifted jejunum; **C** and **D:** Both fixation suture (solid blue arrow) and anchor suture (blue dotted arrow) are placed. The anterior wall is anastomosed with interrupted sutures. CHD: common hepatic duct.

Bridgewater, NJ, USA) (Fig. 1B). This ligation is extracorporeally performed. At the edge on the patient's left side (i.e., the side near the main surgeon), an anchoring suture without ligation is placed with the same absorbable monofilament suture (Fig. 1B). The posterior walls of the bile duct and jejunum are thus easily confirmed during anastomosis, because suture at the near end is not ligated. This ligation is extracorporeally performed after completion of the posterior suture. The fixation and anchoring sutures are adequately set through the abdominal wall as for laparoscopic choledocholithotomy, at different points from the laparoscopic trocars with a trocar site closure device (Endo Close; Medtronic, Dublin, Ireland).

Laparoscopy provides an excellent overhead view with adequate magnification and light source. As described above, optimizing the direction of the main surgeon's forceps is also advantageous for anastomotic procedures (Fig. 1C and D). Cholangiojejunostomy is intracorporeally performed with absorbable monofilament suture (PDS II, 4-0, violet, RB-1; Ethicon, Inc.). The posterior wall is anastomosed with running or interrupted sutures (Fig. 2A and B). Thereafter, the anterior wall is anastomosed with interrupted sutures (Fig. 2C and D). A drain is placed under the anastomosis, and total bilirubin level in the drain discharge is checked postoperatively.

Laparoscopic HBP surgery for benign diseases has several advantages, including excellent magnified visualization and an adequate surgical field located on the right anterior side of the body [12]. Laparoscopic surgeons should be proficient in a variety of techniques and devices; laparoscopic choledochojejunostomy require skillful manipulation of the forceps [12]. This advanced surgery is feasible in the clinical setting. Even when endoscopic transpapillary biliary drainage is emergently required in patients with acute cholangitis, subsequent laparoscopic HBP surgery for benign diseases of the EHBD have an excellent clinical course and acceptable outcomes [3,4]. Even though emergent EST is easier than elective laparoscopic surgery, transpapillary biliary drainage without EST is the initial treatment for acute cholangitis. Completion of EST results in destruction of the physiological function of Oddi's sphincter. Ill-considered use of EST should be avoided [2]. To preserve sphincter function, emergent EST should be performed only in special situations (e.g., elderly patients with critical comorbidities, severe disease, prolonged jaundice, or severe dysfunction of Oddi's sphincter resulting from previous surgeries [1,10,13,14]. Persistent dysfunction of Oddi's sphincter will cause recurrent stones in the bile duct even after choledocholithotomy or EST [2,10,11], and laparoscopic choledochojejunostomy is a possible therapeutic option to provide biliary diversion for these refractory stones [2,12].

A laparoscopic approach is safe and feasible for choledochojejunostomy [3,4,12,15], though a protracted learning curve may

be required even for experienced HBP surgeons [3]. Laparoscopic approach can provide an adequate setting for surgical procedures with an excellent surgical field for choledochojejunostomy [12].

In conclusion, laparoscopic choledochojejunostomy is feasible. Safe laparoscopic HBP surgery is the recommended approach for benign diseases of the EHBD.

Contributors

HT wrote the first draft. HT originally drew all illustrations and schemas. HT, AY, YM and YD mainly performed these laparoscopic surgeries. IT, YS and TK provided academic opinions. All authors assessed the manuscript. HT and US are guarantors.

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Competing interest

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