

Comparison of Single-Incision and Conventional Laparoscopic Cyst Excision and Roux-en-Y Hepaticojejunostomy for Children with Choledochal Cysts

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Received: 31 January 2015 / Accepted: 5 September 2015 / Published online: 12 September 2015
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Abstract The purpose of this study was to elucidate the potential benefits of single-incision laparoscopic Roux-en-Y hepaticojejunostomy comparing the conventional laparoscopic procedures. From January 2013 to July 2013, 17 consecutive children with choledochal cysts received single-incision laparoscopic Roux-en-Y hepaticojejunostomies by a single surgeon at our institution. Seventeen standard laparoscopic hepaticojejunostomies of consecutive children with choledochal cysts from July 2012 to December 2012 were employed as control. Demographic and perioperative information was identified retrospectively using clinic and hospital records including gender, age, total operating time, estimated blood loss, time to oral intake, drainage removal time, postoperative complications, and postoperative hospital stay. One patient was converted to open surgery and another 8-year-old boy converted to conventional four-port laparoscopic procedure. There were no significant differences between the conventional laparoscopic group and the single-incision laparoscopic group with regard to preoperative variables including age ($P=0.697$) and sex distribution ($P=1.000$). For mean operative time (209.9 ± 7.5 vs 204.1 ± 6.9 min, $P=0.951$), estimated blood loss (10.7 ± 1.1 vs 13.4 ± 1.7 ml, $P=0.103$), time to oral intake (3.73 ± 0.21 vs 3.77 ± 0.20 days, $P=0.889$), drainage removal time (4.20 ± 0.45 vs 4.06 ± 0.23 days, $P=0.067$), and postoperative hospital stay (7.60 ± 0.25 vs 7.41 ± 0.21 days, $P=0.627$), the differences were also nonsignificant. Nevertheless, this technique demonstrated improved cosmetic

outcomes comparing with the conventional laparoscopic group. The results showed better cosmetic results and comparable postoperative outcomes. However, well-designed prospective studies are warranted to better address this issue.

Keywords Choledochal cysts · Roux-en-Y hepaticojejunostomies · Single-incision laparoscopy · Minimally invasive

Introduction

Choledochal cysts are congenital anomalies of the bile ducts and are defined as abnormal, disproportionate, cystic dilatation of the biliary duct. They account for approximately 1 % of all benign biliary diseases. It is a relatively rare entity in the west but is more commonly seen in eastern regions of the world, with an incidence of 1 in 1000 in Japan [1]. The female-to-male ratio varies between 3:1 and 4:1 in most series [2]. In general, choledochal cysts require surgical intervention in order to avoid complications associated with pancreaticobiliary reflux. Currently, complete cyst excision with cholecystectomy followed by biliary reconstruction using a Roux-en-Y hepaticojejunostomy is the treatment of choice [2–4].

The advantages of laparoscopic surgery are well documented with less surgical trauma, less bleeding, smaller scars, and faster recovery. Laparoscopic hepaticojejunostomy for children with choledochal cysts has been gaining popularity [5, 6]. Single-incision laparoscopic surgery has become popular in pediatric surgeons to achieve minimal surgical trauma recently [7]. As representing the next step in the evolution of standard laparoscopic surgery, it is performed through a single small skin incision, often partially concealed at the umbilicus, and patients may experience less postoperative pain and fewer

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port site-related complications. Single-incision laparoscopic Roux-en-Y hepaticojejunostomy was introduced by Diao et al., and they achieved comparable short-term results with conventional laparoscopic hepaticojejunostomy [8].

However, the single-incision laparoscopic procedure requires specialized curved or articulating instruments that may require extensive training in technically challenging and difficult procedures. Whether this approach results in improved peri-operative outcomes remains under investigation. Before gaining wider acceptance, this technique must be compared to standard laparoscopic hepaticojejunostomy with accumulation of evidence. Thus, to further elucidate the potential benefits of this approach using a more homogenous patient cohort, we present our initial experience of 17 consecutive single-incision laparoscopic Roux-en-Y hepaticojejunostomy by a single surgeon.

Patients and Methods

Study Population

From January 2013 to July 2013, 17 consecutive children with choledochal cysts were admitted, 10 of which were cystic type and the other 7 were fusiform type. Single-incision laparoscopic Roux-en-Y hepaticojejunostomies were performed at our institution by a single surgeon. Seventeen standard laparoscopic hepaticojejunostomies of consecutive children with choledochal cysts from July 2012 to December 2012 were employed as control. Informed consent was obtained from all parents and the standard and single-incision laparoscopic procedures were approved by the Institutional Review Board.

Data Collection

Data were retrospectively collected after patients had provided the informed consent. Demographic and perioperative information was identified retrospectively using clinic and hospital records. The clinical parameters analyzed in this study were total operating time—time from operative field skin preparation to skin closure, estimated blood loss (EBL)—as recorded in the operative records, time to oral intake—time from the end of the operation to food intake, drainage removal time—time from the end of the procedure to drainage removal, postoperative complications—an unexpected event related to the operation within hospitalization, and postoperative hospital stay—time from the end of the procedure to discharge. Abdominal ultrasonography and laboratory tests were employed to study the postoperative complications.

Postoperative complications were classified using the modified classification of Clavien–Dindo system [9]. Grades I and II complications are regarded as minor complications necessitating noninvasive interventions; grade III complications are

defined as patients required surgical, endoscopic, or radiological intervention; life-threatening complication (including central nervous system complications) requiring intermediate care or intensive care unit management are classified into grade IV complications.

Surgical Technique

The patient was laid on the operation table in a Trendelenburg position to aid in exposure and dissection. The monitor was placed at the upper right and the operating surgeon stood at the foot of the bed between the patient's legs. A longitudinal incision was made at the umbilical skin and a 5-mm trocar was inserted in the middle and carbon dioxide pneumoperitoneum was established with a pressure of 8–12 mmHg. Accesses were obtained via the umbilicus bilaterally about 10–15 mm from the midline to place two 3-mm trocars, for working and assistant instruments (Fig. 1).

The gallbladder fundus and anterior wall of the common hepatic duct were suspended separately with extracorporeal stay sutures of 2-0 silk to expose the hepatic hilum. With the traction sutures reserved, the gallbladder dissection was then started from the fundus with a monopolar electrocautery to the anterior wall of the cyst. Subsequently, the anterior cyst wall was opened and the contents were evacuated for decompression. Another 2-0 silk suture was used for suspension of distal end of the cyst (Fig. 2), and the cyst was dissected retrograde



Fig. 1 External view of the three trocar ports via the umbilicus and two extracorporeal stay retraction sutures through the abdominal wall

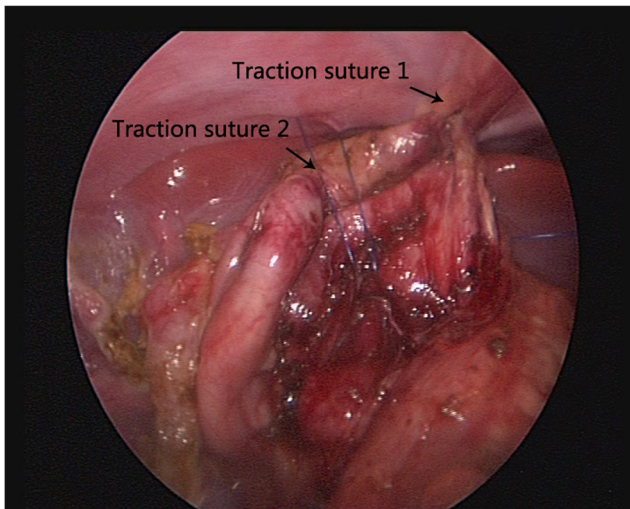


Fig. 2 Internal view of the two extracorporeal stay sutures for hepatic hilum exposure and suspension of distal end of the cyst, respectively

to the proximal end close to the cyst wall using electrocautery. In patients with cystic dilatations, the cysts were transected and for the ones with fusiform dilatations, the stenotic distal ducts were ligated. The common hepatic duct was then trimmed at its junction with the cyst. The specimen of the gallbladder and the cyst were then removed from the expanded umbilical incision with the common hepatic duct suspension suture reserved.

The jejunum was pulled out through the umbilical incision and then the jejunal Roux loop was prepared extracorporeally. Briefly, the jejunum was opened at about 10 cm below Treitz ligament and the distal end was closed. Then we performed the end-to-side jejunojejunostomy with a 20- to 25-cm Roux loop tailored. After the pneumoperitoneum being reestablished, the jejunal Roux loop was brought to the hilum through the retrocolic route. Then the intestinal wall opposite to the mesentery side was opened according to the diameter of the common hepatic duct. Subsequently, end-to-side hepaticojejunum anastomosis was accomplished with double-armed 5-0 PDS suture. The anastomosis started at 3 o'clock position of common hepatic duct and proceeded clockwise to 9 o'clock continuously to close the posterior wall (Fig. 3), the anterior wall was closed similarly with the other needle anticlockwise from 3 o'clock to 9 o'clock continuously, and endoscopic knotting was then conducted at 9 o'clock. Finally, the retraction sutures were removed and a suction drain was placed in the subhepatic region via the umbilical incision (Fig. 4a).

Outcome Analysis

Statistical analyses were performed using SPSS 19.0 software (SPSS, Inc., Chicago, IL). Data are reported as mean plus or minus standard deviation (SD). The *t* test and chi-square test (or Fisher's exact test) were used to examine differences

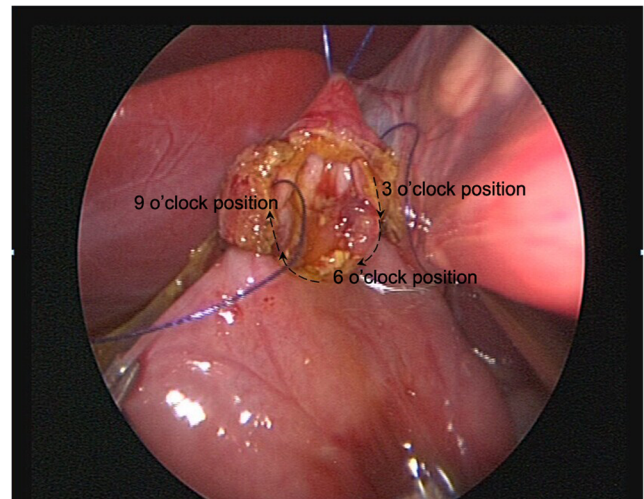


Fig. 3 End-to-side hepatico-jejunum anastomosis with double-armed 5-0 PDS suture started at 3 o'clock position of common hepatic duct and proceeded clockwise to 9 o'clock continuously to close the posterior wall. The anterior wall was closed similarly with the other needle anticlockwise from 3 o'clock to 9 o'clock, and endoscopic knotting was then conducted at 9 o'clock

between the groups. Two-tailed *P* values <0.05 were considered significant.

Results

One patient was converted to open surgery due to persistent intraoperative bleeding, and another 8-year-old boy converted to conventional four-port laparoscopic procedure because of elasticity deficiency of the umbilical access. Hence, 15 patients were treated with single-incision laparoscopic Roux-en-Y hepaticojejunostomies and 17 patients treated with conventional laparoscopic Roux-en-Y hepaticojejunostomies from July 2012 to December 2012 were employed as the control group. Patient demographic data and peri-operative outcomes are shown in Table 1. There were no significant differences between the conventional laparoscopic group and the single-incision laparoscopic group with regard to pre-operative variables including age ($P=0.697$, *t* test) and sex distribution ($P=1.000$, chi-square test).

The mean operative time in the single-incision laparoscopic group was comparable with that in the conventional laparoscopic group (209.9 ± 7.5 vs 204.1 ± 6.9 min, $P=0.951$, *t* test). However, we showed lower EBL in the single-incision laparoscopic group than the conventional laparoscopic group, but failed to achieve a significant difference (10.7 ± 1.1 vs 13.4 ± 1.7 ml, $P=0.103$, *t* test). No blood transfusion was required in both groups. For time to oral intake (3.73 ± 0.21 vs 3.77 ± 0.20 days, $P=0.889$, *t* test), drainage removal time (4.20 ± 0.45 vs 4.06 ± 0.23 days, $P=0.067$, *t* test), and postoperative hospital stay (7.60 ± 0.25 vs 7.41 ± 0.21 days, $P=0.627$, *t* test), the differences were also nonsignificant.

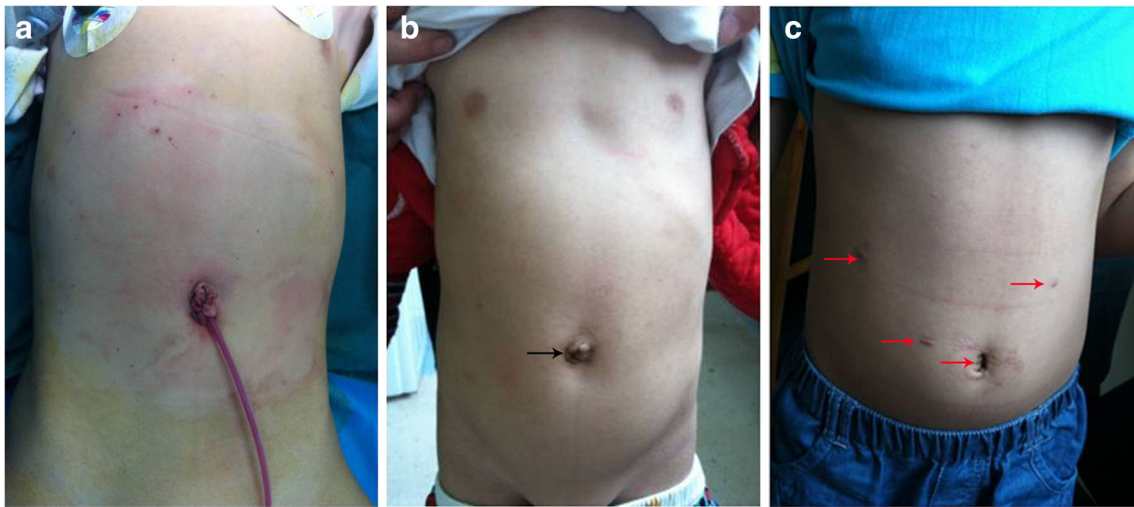


Fig. 4 The suction drain was placed in the subhepatic region via the umbilical incision (a) and improved cosmetic outcomes were achieved in the single-incision laparoscopic group. Scars of children (black

arrowed) who received single-incision laparoscopic procedures (b) and scars of children (red arrowed) received conventional laparoscopic operations (c)

The mean follow-up time for the single-incision laparoscopic group was 16.3 days, and the mean follow-up time for the conventional laparoscopic group was 15.7 days. There were no differences regarding postoperative complications in the two groups according to the modified classification of Clavien-Dindo system (1/15 vs 1/17, $P=1.000$, chi-square test) No pancreatic leak, anastomotic stenosis, cholangitis, pancreatitis, intestinal obstruction, and wound infection were

encountered in the single-incision laparoscopic group. One child in the single-incision laparoscopic group developed bile leak postoperatively, and spontaneous healing achieved after 10 days of conservative treatment. Wound infection occurred in another boy of the conventional laparoscopic group and achieved secondary healing after dressing changing. Postoperative serum bilirubin dropped to the normal level except one case with liver cirrhosis, which showed an improvement.

Table 1 Comparison of demographic parameters, perioperative variables for patients undergoing cyst excision and Roux-en-Y hepaticojejunostomy either by single-incision and conventional laparoscopic approach

	Conventional laparoscope group ($n=17$)	Single-incision laparoscope group ($n=15$)	P value
Gender			
Male (%)	13	12	1.000 ^a
Female (%)	4	3	
Age (years)			
Median (range)	4.7±0.8 (0.7–14)	3.5±0.9 (0.5–14)	0.697 ^b
Total operating time (min)			
Median (range)	204.1±6.9 (150–252)	209.9±7.5 (150–241)	0.951 ^b
Estimated blood loss (ml)			
Median (range)	13.4±1.7 (4–30)	10.7±1.1 (5–20)	0.103 ^b
Time to oral intake (days)			
Median (range)	3.77±0.20 (3–5)	3.73±0.21 (3–5)	0.889 ^b
Drainage removal time (days)			
Median (range)	4.06±0.23 (3–5)	4.20±0.45 (3–10)	0.067 ^b
Postoperative hospital stay (days)			
Median (range)	7.41±0.21 (7–10)	7.60±0.25 (7–10)	0.627 ^b
Postoperative complications			
Grades I and II	1	1	1.000 ^a
Grade III	0	0	
Grade IV	0	0	

^a Chi-square test

^b t test

Similarly, serum liver enzymes after the surgeries in both groups also demonstrated significant improvements. No hepatic hilar effusions and pneumobilia were encountered with postoperative abdominal ultrasonography in both groups. Nevertheless, this technique demonstrated improved cosmetic outcomes (Fig. 4b, c) comparing with the conventional laparoscopic group.

Discussion

Choledochal cysts require surgical intervention in order to avoid complications associated with pancreaticobiliary reflux. They are usually infancy or childhood problem, and approximately 75 % of diagnoses are made at the early age of the patients [1, 10]. Previous studies, however, have suggested that visible scarring in children may lead to low self-esteem, impaired socialization skills, and decreased self-ratings of problem-solving ability [11, 12]. With the interest in scarless surgery growing rapidly over the past decade, the children deserve nothing but the minimal amount of discomfort and best cosmetic results.

Hepatoduodenostomy and Roux-en-Y hepatojejunostomy are both commonly performed methods of reconstruction after excision of choledochal cysts. Hepatoduodenostomy is more physiologic and technically easy; however, surgeons often prefer a Roux-en-Y reconstruction for its safety. Narayanan and colleagues [13] conducted a meta-analysis, which showed that it is comparable in most postoperative outcomes between the two procedures; nevertheless, hepatoduodenostomy demonstrated higher postoperative reflux/gastritis than hepatojejunostomy but a shorter hospital stay. Laparoscopic hepatojejunostomy for children with choledochal cysts has been gaining popularity recently. Diao et al. [5] compared the intermediate-term results of two large cohorts of children with choledochal cysts who underwent laparoscopic and open surgeries and drew a conclusion that laparoscopic hepatojejunostomy is safe and effective as its intermediate-term results are comparable to open surgery. In this study, all the reconstructions were performed with Roux-en-Y hepatojejunostomies. Natural orifices present a novel opportunity for scar-free major surgery and potential convalescence benefits. Over the last few years, single-incision surgery has been increasingly applied to pediatric surgical practice [14–16].

In the current study, we presented our initial experience of single-incision laparoscopic Roux-en-Y hepatojejunostomies. Results suggested a better cosmetic result was achieved and the postoperative outcomes were comparable to conventional laparoscopic hepatojejunostomy regarding to total operating time, EBL, time to oral intake, drainage removal time, postoperative complications, postoperative hospital stay, serum liver enzymes, and serum bilirubin levels.

Depending on the thin and excellent elasticity properties, the umbilical skin was longitudinally cut and stretched horizontally. The distance of two 3-mm trocars could be maintained as 2.5–3.0 cm, ensuring no interference between each other. Three trocars in one incision were placed through independent puncture site to avoid CO₂ leaked. Good exposure of the operative field was crucial. With the use of one 5-mm trocar, two 3-mm trocars, and an extended 30° camera, the operational space and freedom were improved. Suspensions with extracorporeal stay sutures were also invaluable for the operation. Hansen et al. [7] advocated the use of an additional instrument placed percutaneously through a separate stab incision to facilitate the exposure of surgery field. Nevertheless, we believe the limited room could be occupied with the use of the additional instrument. In our experience, suspensions with two extracorporeal stay sutures were sufficient to ensure the operation process. The first traction suture was placed through the serous layer of the gallbladder fundus close to the liver, so the liver would be still suspended after the separation of the gallbladder. The location of the second suture generally depended on the left lobe of liver, which usually inserted at the left subcostal. After suturing the anterior wall of common hepatic duct and common bile duct junction, the needle was then withdrawn below the xiphoid process to suspend the left lobe of liver in a V shape. The third traction suture was placed through the anterior wall of the distal cyst and pulled upward to expose the junction of the cyst and pancreas. For children with giant cysts, sometimes one suture was not enough to expose the cyst bottom, two traction sutures may need.

Intraoperative bleedings are considered to be responsible for a considerable proportion of laparoscopic surgeries converted to open operations. In our series, one case was converted to open surgery due to persistent intraoperative bleeding which cannot be stop with the vascular clamp. To maximally reduce the intraoperative bleeding, our experience was as follows: (1) We use electrocoagulation for the separation of gallbladder and the cystic wall rather than electrical cut. And blunt dissection should be avoided. (2) For the management of the cystic artery, the main branches were coagulated first, and then the dissociation was conducted close to the cystic wall. (3) The dissociation of the cyst posterior wall should be started from the distal end to the proximal end under the laparoscopic vision to avoid the damage of portal vein. (4) Excessive dissociation should be avoided before the transection of the common hepatic duct and common bile duct junction. (5) For bleeding that cannot be stopped by electrocoagulation, the operating surgeon used one laparoscopic clamp to press the hemorrhagic region, then an extracorporeal needle with suture was employed to suture the hemorrhagic region, and single hand knot was completed to stop the bleeding.

Single-incision laparoscopic cyst excision and Roux-en-Y hepatojejunostomy for children is challenging; the appropriate patients selection is extremely important. In our series, one

obese 8-year-old boy received a converted conventional four-port laparoscopic procedure because of elasticity deficiency of the umbilical access. All the 15 patients who had single-incision laparoscopic surgeries had good umbilicus elasticity, which facilitated the handling of the instruments. The umbilicus elasticity, in our initial experiences, is one of the key points for single-incision laparoscopic surgeries. Generally, children no more than 8-year-old could be included for this procedure as their umbilici have less fat and appropriate elasticity. We do not take the cyst size into account as the determinant that whether a child is a suitable single-incision laparoscopic operation candidate. For large cysts, usually, satisfying working space could be obtained after cyst decompression, and the cysts could almost always be removed.

Hepaticojejunostomy is the most difficult part in the absence of the assistant's help. Double-armed 5-0 PDS was modified with a final length of about 20 cm. The anastomosis started at 3 o'clock position and proceeded clockwise to 9 o'clock continuously to close the posterior wall, and the anterior wall was closed similarly with the other needle anticlockwise from 3 o'clock to 9 o'clock. Accurate positioning of the anastomosis is critically important, which is facilitating the anastomosis process. Using of the 20-cm-length suture, neither interferes the operation procedures nor disturbs the knotting. PDS suture is smooth and absorbable; thus, we advocate continuous suture for the anastomosis process to tie the knot tightly.

The results obtained in this study should be interpreted with caution; several limitations of this study should be noted. First, the study is susceptible to all limitations and biases inherent in a retrospective design. In the early stage of this technique, prospective randomization controlled studies are not practical. Nevertheless, we are planning work with a prospective study design to better address this issue. Second, less postoperative pain is theoretically one of the advantages for single-incision laparoscopic surgeries comparing with the conventional laparoscopic surgeries. However, postoperative pain was not evaluated, as neither visual analog scale nor analgesic requirement was efficacious for children. And furthermore, we failed to demonstrate the cosmetic advantage in an objective manner. Third, this is a small-size study at a single institution; well-designed study with multiple institutions is needed.

Anyhow, our initial experience with single-incision laparoscopic cyst excision and Roux-en-Y hepaticojejunostomy for children is encouraging. The results showed a better cosmetic result was achieved and the postoperative outcomes were comparable to conventional laparoscopic hepaticojejunostomy in regard to the total operating time,

EBL, time to oral intake, drainage removal time, postoperative complications, and postoperative hospital stay. Considering the flaws of the current study, well-designed prospective studies are warranted to better address this issue.

Conflict of Interest None of the authors have any conflicts of interests.

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