



Modified single-port versus multiport laparoscopic choledochal cysts excision and Roux-en-Y hepaticojejunostomy: a retrospective comparative cohort study

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Background: The feasibility, benefit, and safety of multiport laparoscopic choledochal cyst (CDC) excision and Roux-en-Y hepaticoenterostomy (MPCH) have been consistently confirmed. Single-port laparoscopic CDC excision and Roux-en-Y hepaticoenterostomy (SPCH) has advantages of less traumatic and more cosmetic beneficial, it has been reported in some case series, but it is technically challenging. We propose a modified technique to reduce technical difficulty in performing SPCH. The safety and feasibility of modified SPCH were compared with those of conventional multiport laparoscopic CDC excision.

Methods: A total of 43 consecutive patients who diagnosed with CDC by preoperative magnetic resonance cholangiopancreatography (MRCP) and underwent SPCH (n=24) and MPCH (n=19) for choledochal cyst (CDC) by a single surgeon between January 1, 2018, and January 1, 2021, were enrolled. The baseline clinical characteristics, efficacy and safety outcomes of short-term were compared.

Results: The baseline clinical characteristics of the MPCH and SPCH groups are comparable. Average postoperative length of hospital stay was shorter in the SPCH group than in the MPCH group, but the difference was not statistically significant (7.00 *vs.* 7.58 days; $P>0.99$). The operation time (281.75 *vs.* 277.32 min; $P=0.58$) and the amount of blood loss (9.33 *vs.* 16.68 mL; $P=0.57$) were similar in both groups. A significantly greater number of drainage tubes were placed in the MPCH group compared to the SPCH group (11 *vs.* 5; $P=0.01$). One patient suffered from hepaticoenterostomy anastomosis stricture in the SPCH group.

Conclusions: The short-term outcome of modified SPCH is comparable with MPCH according to our study. It is easily adaptable treatment of CDC.

Keywords: Single-port laparoscopic surgery; choledochal cysts (CDCs); Roux-en-Y hepaticoenterostomy; enhanced recovery after surgery

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Introduction

Choledochal cyst (CDC) is one of the most common congenital biliary malformations in the Asian population, with an incidence as high as 1:1,000 (1). Early diagnosis and surgical intervention are the best ways to prevent perioperative complications and improve prognosis (2,3). Cyst excision and Roux-en-Y hepaticoenterostomy is the first-line treatment for patients with CDC (4). With the rapid advance in surgical technique and equipment, laparoscopic cyst excision and Roux-en-Y hepaticoenterostomy has now been accepted as the preferred approach and provides favorable short- and long-term outcomes (3,5). Single-port laparoscopic surgery is a new technique in which the entire procedure is performed through an incision with a single port containing 3 or 4 small ports. The feasibility and safety of single-port laparoscopic CDC excision and Roux-en-Y hepaticoenterostomy (SPCH) have been confirmed in some case series (6-9), and it has demonstrated cosmetic advantages, the likelihood of less pain, and a shorter recovery period due to the reduction of trocar sites (10). However, SPCH is a technically challenging procedure and requires the surgeon to have abundant experience with the traditional laparoscopic procedure; moreover, single-port operations usually last 30% longer than their traditional laparoscopic counterparts and are more likely to produce incision complications (11).

In this paper, we propose a modified SPCH technique

to overcome the difficulties of starting the single-port procedure and to aid those surgeons who customarily perform conventional multiport laparoscopic cyst excision and Roux-en-Y hepaticoenterostomy (MPCH) to transition to SPCH. The safety and feasibility of modified SPCH in the treatment of CDC were compared to those of MPCH. We present the following article in accordance with the STROBE reporting checklist (available at <https://tp.amegroups.com/article/view/10.21037/tp-22-557/rc>).

Methods

Study population and design

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the ethics committee of Guangzhou Women and Children's Medical Center (GWCMC) [approval No. (2022) 083A01]. Individual consent for this retrospective analysis was waived. A retrospective comparative cohort study was conducted to review patients who underwent SPCH and MPCH in GWCMC between January 1, 2018, and January 1, 2021, with 43 consecutive patients ultimately being enrolled. At the time of operation, the parents were informed about the treatments, and written consent was obtained. Patients diagnosed with CDC by preoperative magnetic resonance cholangiopancreatography (MRCP) and operated by a single surgeon (Zhe Wang) were included. Patients with different diagnoses confirmed during the procedure or those with severe perioperative complications were excluded from the study.

Between January 2018 and March 2020, MPCH was routinely performed in the authors' department. After March 11, 2020, we began to practice SPCH, and it was offered to parents as a choice. MPCH was performed only when parents refused SPCH. All operations were performed by a single experienced surgeon. The main operative principles for SPCH and MPCH were similar. Data including demographic characteristics, clinical presentation, operative results, and complications of all patients were obtained from the medical records and reviewed retrospectively; patients were followed-up clinically for at least 1 year; and the postoperative complications were documented. The patients were divided into SPCH and MPCH groups according to the surgical treatment received. The outcome was postoperative length of stay (LOS), operation time (skin to skin), amount of blood loss, and postoperative complications.

Highlight box

Key findings

- We propose a modified single-port laparoscopic choledochal cyst excision and Roux-en-Y hepaticoenterostomy (SPCH) technique to overcome the difficulties of starting the single-port procedure, and to aid surgeons who customarily perform conventional multiport laparoscopic cyst excision and Roux-en-Y hepaticoenterostomy (MPCH) to transition to SPCH.

What is known and what is new?

- The feasibility, benefit, and safety of MPCH have been consistently confirmed.
- The short-term outcome of modified SPCH is comparable with MPCH according to our study. It is easily adaptable treatment of CDC.

What is the implication, and what should change now?

- Modified SPCH is easier for surgeons to master, however, long-term outcomes and prospective studies are needed in future investigations.

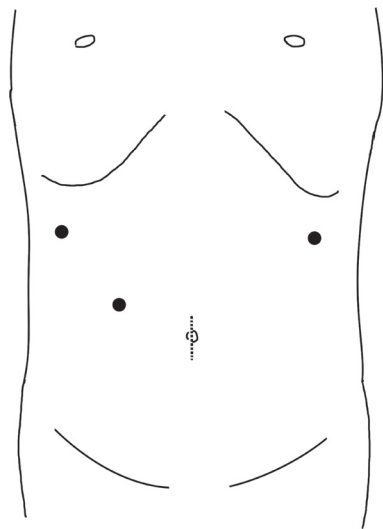


Figure 1 The trocar arrangement of MPCCH. MPCCH, multiport laparoscopic choledochal cyst excision and Roux-en-Y hepaticoenterostomy.

Surgical procedures

Multiport laparoscopic cyst excision and Roux-en-Y hepaticoenterostomy

Patients were placed in a supine and head-up position with the operator on the right side and assistant on the left side. A 10-mm vertical incision was made on the umbilical site, and a 12-mm trocar (5- to 10-mm port) was introduced through the incision. Carbon dioxide pneumoperitoneum was established at a pressure of 8–10 mmHg. Another three 3-mm trocars were punctured under laparoscopic surveillance. The trocar arrangement is shown in *Figure 1*. The round ligament was retracted towards the xiphoid by a 3–0 Prolene suture introduced through the skin. After the diagnosis was confirmed, the gallbladder was released from the gallbladder bed, the cystic duct was dissected to the common hepatic duct, the peritoneum on the CDC was opened, and the cyst was dissected from the proximal to distal direction. Care was taken when the dissection plane entered the pancreas. Distal common bile ducts ≤ 1 mm were coagulated and cut without ligation, while those >1 mm were ligated and cut. The cyst was then gradually lifted by releasing its posterior wall. After the dissection plane was joined at the common hepatic duct on both the ventral and dorsal sides, the cyst was opened, and the bile was drained. The common hepatic duct, cystic duct, both sides of the hepatic duct, and, if present, an aberrant hepatic duct were examined carefully from the mucosal side in

the CDC. The CDC was then cut above the cystic duct and completely removed, and an 8- to 10-mm diameter patch was left around the opening of common hepatic duct for hepaticoenterostomy. The Roux-en-Y limbs were established by delivering the intestine through the enlarged umbilical incision (3–4 cm), for which a 15- to 20-cm input limb and a 15- to 20-cm bile limb were used. Following this, the end of the bile limb was closed by running sutures. After the Roux-en-Y limbs were completed, the intestine was placed back into the abdominal cavity, and the pneumoperitoneum was reestablished by closure of the umbilical incision. The bile limb was brought to the hilum through the mesentery of the transverse colon, and then an 8- to 10-mm incision was made at the contralateral margin of the mesentery 5 mm to the end of the bile limb. Two 9- to 13-cm long 13-mm needle 6-0 polydioxanone plus antibacterial suture (PDP) were tied to each other at the end and introduced into the abdominal cavity for hepaticoenterostomy. The end-to-side hepaticoenterostomy was established by running sutures. The anastomosis started at the 3 o'clock position using 1 needle, with the posterior wall being sutured first, and was finished at the 9 o'clock position. After work on the posterior wall was performed, the suture was left in place without knotting, and then the anterior wall was sutured with the other needle from the 3 to 9 o'clock positions. After the 2 sutures met at the 9 o'clock position, a knot was made with the 2 sutures to finish the anastomosis. Mesenteric hiatuses were secured, and the operative field was irrigated carefully. A drainage tube was placed only if postoperative bile/pancreas leakage or bleeding was suspected.

Single-port laparoscopic CDC excision and Roux-en-Y hepaticoenterostomy

Patients were placed in a supine and head-up position with both the operator and assistant on the left side. A curve incision was made at the skin fold on the upper edge of the umbilicus, and then the incision was lengthened 5 mm horizontally on both sides (*Figure 2*). A 20- to 30-mm tunnel was established by blunt dissection through the incision toward the surgical field (the hepatic hilum) above the anterior rectus sheath, after which the linea alba and the rectus were opened horizontally at the end of the tunnel, creating a 30- to 35-mm incision entering the abdominal cavity. A 3-operative-site (3–5 mm \times 2, 5–10 mm \times 1) 35-mm ellipse shape single port (Surgaid IIIA-3B-35 \times 100, Surgaid Medical Co, Xiamen, China) was introduced through the incision (*Figure 3*). Carbon dioxide

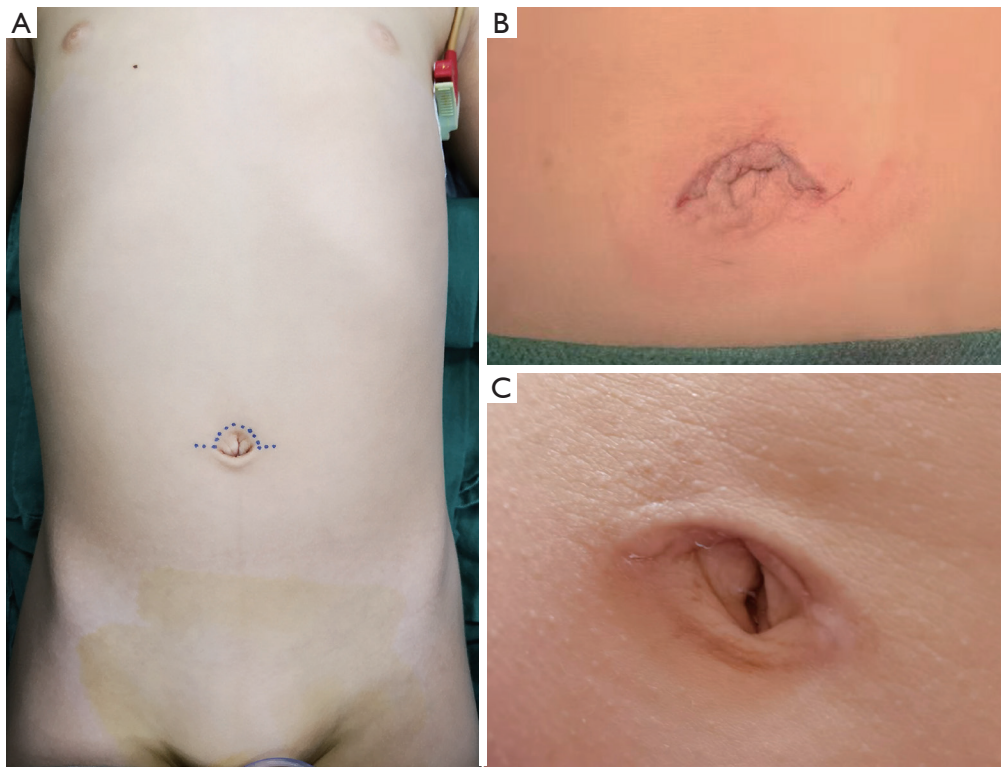


Figure 2 The umbilicus curve incision made at the skin fold in the SPCH procedures. (A) Incision design. (B) Incision appearance after the procedure. (C) Incision appearance 1 month after the procedure. SPCH, single-port laparoscopic choledochal cyst excision and Roux-en-Y hepaticoenterostomy.

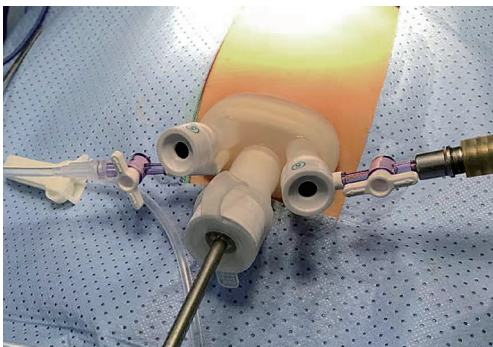


Figure 3 The 3-operative-site (3–5 mm × 2, 5–10 mm × 1) 35-mm ellipse-shapes single port (Surgaid IIIA-3B-35 ×100) used for SPCH. SPCH, single-port laparoscopic choledochal cyst excision and Roux-en-Y hepaticoenterostomy.

pneumoperitoneum was established at a pressure of 8–10 mmHg. Conventional 5-mm 30° laparoscope and straight 3-mm laparoscopic instruments were used. CDC dissection followed the same procedure as described for

MPCH. Retraction sutures were introduced through skin and attached to the gallbladder bed and/or CDC to help expose the surgical field. The Roux-en-Y loop was established by delivering the intestine through the single-port incision. Drainage tubes were not routinely placed.

Perioperative management and data collection

Information of the patients was collected, including age, gender, Todani classification, symptoms, prenatal diagnosis information, and diameter of the cyst. Operative data were documented, including the operative duration, amount of blood loss, postoperative LOS, drainage placement, and postoperative complications. The discharge criteria were the same between the SPCH and MPCH patients and included no severe complications, no complaints of pain, and normal oral feeding. Hepatic biochemistry and ultrasound were reviewed in the first month of postoperative follow-up, and MRCP was reassessed 6 months postoperatively. The occurrence of postoperative complications was documented.

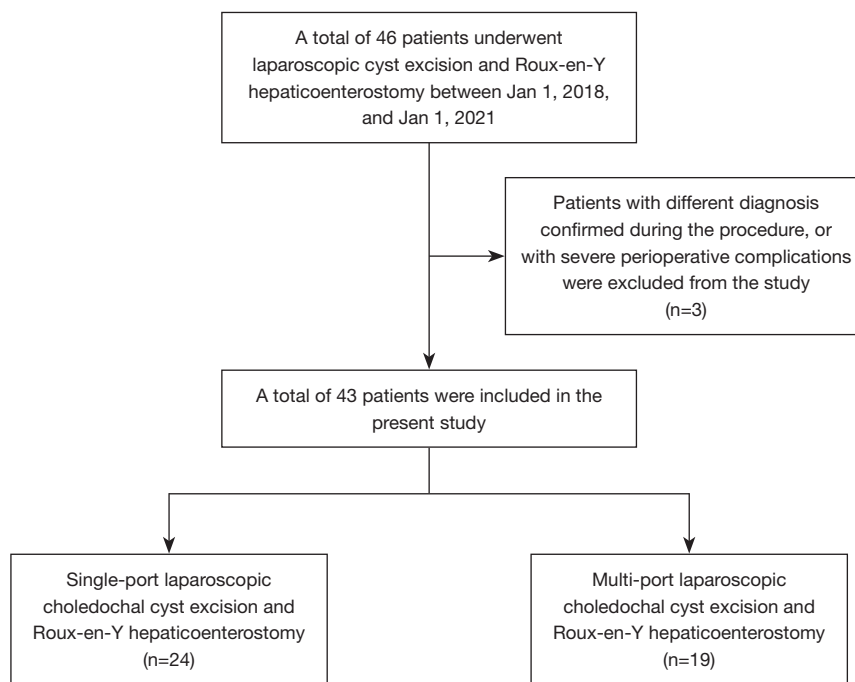


Figure 4 Flow diagram of the patients identified, included, and excluded.

Statistical analysis

Statistical analysis was performed with GraphPad Prism 9 version 9.0.0 (GraphPad Software, San Diego, CA, USA). To compare continuous variables, Student's *t*-test was used when the data were distributed normally, while the Mann-Whitney test was used when data were distributed nonnormally. The chi-square or Fisher exact test was used for categorical variables. A *P* value <0.05 was considered statistically significant.

Results

Baseline characteristics

Between January 1, 2018, and January 1, 2021, 46 patients (0–96 months) underwent laparoscopic cyst excision and Roux-en-Y hepaticenterostomy by a single surgeon. Three patients were excluded from the study: the first patient was confirmed with hepatic duct junction cyst during the operation, and the procedure was converted to an open approach; the second patient was confirmed with right hepatic duct diverticulum cyst with normal common hepatic duct and normal common bile duct, and the cyst was resected without performance of Roux-en-Y biliary reconstruction; and the third patient was complicated by

hepatic cirrhosis and severe portal hypertension, and the procedure was converted to an open approach to achieve better hemostasis. In all, 43 patients were included in the present study (Figure 4). The baseline data of the patients are shown in Table 1. There were no statistically significant differences between the MPCH group and the SPCH group in the baseline data, the baseline is comparable between these two groups.

Perioperative outcomes

The surgical information and outcomes are listed in Table 2. The patients were followed-up for 20.4 months (12–30 months). Average postoperative LOS was shorter in the SPCH group than in the MPCH group, but the difference was not statistically significant (7.00 vs. 7.58 days; *P*>0.99). No significant difference was found between SPCH and MPCH groups in the operation time (281.75 vs. 277.32 min; *P*=0.58) or the amount of blood loss (9.33 vs. 16.68 mL; *P*=0.57). A significantly greater number of drainage tubes were placed in the MPCH group than in the SPCH group (5 vs. 11; *P*=0.01). One patient suffered from anastomosis stricture in the SPCH group, his common hepatic duct diameter for anastomosis was 5 mm, and he was reoperated on after ineffective conventional treatments. No

Table 1 Baseline clinical characteristics of the 24 patients in the SPCH group and the 19 patients in the MPCH group

Baseline clinical characteristics	SPCH (n=24)	MPCH (n=19)	P
Gender (male/female)	7/17	10/9	0.12
Age at operation (month)	14.79 (0–72)	11.42 (0–96)	0.42
Todani's classification			
Ia	9	10	0.32
Ib	3	1	0.42
Ic	6	1	0.08
IVa	5	7	0.25
IVb	1	0	0.37
Symptoms			
Abdominal pain	9	4	0.24
Jaundice	8	7	0.81
Abdominal mass	1	0	0.37
Prenatal diagnosis	13	12	0.55
Diameter of the Cyst (cm)	4.81 (0.7–10)	5.69 (2–17)	0.95

SPCH, single-port laparoscopic choledochal cyst excision and Roux-en-Y hepaticoenterostomy; MPCH, multi-port laparoscopic choledochal cyst excision and Roux-en-Y hepaticoenterostomy.

Table 2 The surgical characteristics and outcomes of SPCH group and MPCH group

Surgical characteristics and outcomes	SPCH (n=24)	MPCH (n=19)	P
Post-operative LOS (days)	7.00 (4–14)	7.58 (5–16)	1.00
Operation time (minutes)	281.75 (170–480)	277.32 (165–435)	0.58
Blood lost (mL)	9.33 (2–50)	16.68 (1–150)	0.57
Needing for drainage	5	11	0.01
Post-operative complications	1	0	0.37

SPCH, single-port laparoscopic choledochal cyst excision and Roux-en-Y hepaticoenterostomy; MPCH, multi-port laparoscopic choledochal cyst excision and Roux-en-Y hepaticoenterostomy; LOS, length of stay.

wound healing problems or incisional hernia was observed during the follow-up, and no other severe complications were observed in either group.

Discussion

We proposed a new technical modification to aid surgeons in starting a single-port procedure for the laparoscopic surgery of CDC. We summarized our experience with SPCH and compared it with conventional MPCH. SPCH has not been widely used due to the technical challenges involved, and there are limited studies available that compare the safety and feasibility between the single-port and multiport procedure in treating patients with CDC (6-9). Our study showed that, using the proposed modification, transformation from MPCH to SPCH was relatively smooth and easy. As a result, SPCH surgery had similar operation time, post operational LOS, and blood loss compared with MPCH; moreover, fewer drainage tubes were placed after SPCH procedures, and the short-term outcomes were favorable.

Laparoscopic cyst excision and Roux-en-Y hepaticoenterostomy has become the standard practice of CDC treatment since it was first performed by Farello *et al.* in 1995 (12). The technical feasibility, postoperative benefit, and safety of this surgery have been consistently confirmed by several large series (3,5,13-15). Previous studies have reported laparoscopic CDC excision and Roux-en-Y hepaticoenterostomy to be associated with shorter operation times, less blood loss, and shorter hospital stays, compared to open procedure (3,16). The smaller incisions and less blood loss result in rapid recovery from surgery (17). However, the MPCH has limitations. For one, the Roux-en-Y hepaticoenterostomy is fashioned extracorporeally by exteriorizing the jejunum through the extended incision of the umbilical port site, the incision should be 3 cm at least to avoid intestine ischemia caused by the mesenteric strangulation, and so, after the anastomosis, the umbilical incision must be closed to reinflate the pneumoperitoneum. These steps incur additional trauma and operation time. Some surgeons prefer a “total laparoscopic CDC operation”, in which the Roux-en-Y anastomosis is performed by several linear cutting staplers (LCSs) intracorporeally; however, there is no suitable LCS for every pediatric age group, and an adult LCS is the only choice in most situations. These LCSs are not reliable when closing thin tissues in small children, and the anastomosis often needs additional restrengthening stitches. Furthermore, a 10-mm LCS needs to be introduced through a 12-mm trocar, for which a long incision is required (18). The cosmetic benefits of single-port laparoscopic surgery are evident when compared with those of conventional multiport surgery (19,20). The

incision number and size are fewer and smaller, respectively, than are those in conventional laparoscopic surgery, which may benefit the enhanced recovery after surgery. SPCH is especially beneficial for neonates and small infants, as they have relatively round abdominal cavities and larger umbilical areas than do older children, characteristics which can further improve operating triangulation. With an extremely large CDC, SPCH can significantly reduce the operation time by enabling the surgeons to dissect the distal cyst from the umbilical incision. If applied appropriately and skillfully, SPCH is an ideal surgical procedure for CDC.

However, the single-port approach is a difficult technique with a long learning curve (8). The first SPCH was reported in 2012 by Diao *et al.* (21). During SPCH, surgeons need to struggle with a narrow visual field and poor operating triangulation (“chopstick effect”). To overcome these difficulties, we designed a tunnel incision to reduce the distance from trocar site to the surgical field. Surgeons move instruments laterally in the MPCH procedure most of the time, so an ellipse-shaped single port can help surgeons to utilize the horizontal space more efficiently. By applying these modifications, the operating triangulation is significantly improved, and in our experience, we encountered less difficulty in converting MPCH to SPCH. Indeed, in this study, all SPCH procedures were comparable with the MPCH procedures, and all patients were discharged without complications, demonstrating excellent outcomes.

Cooperation between the surgeon and the assistant is important since the operative space of this procedure is relatively narrow. To reduce the interference between surgical instruments and scope, a 30° laparoscope is maintained at the middle line (altitude) of the isosceles triangle formed by the 2 instruments (the 2 congruent sides) and the incision (the base of the triangle). When adjusting the viewing angle of the 30° laparoscope, the assistant must take care to avoid deviating the scope from the middle line, which will cause interference between the instruments and the scope. To adjust visual field during the procedure, the scope and instruments should be turned simultaneously to the same direction, with the shape of an isosceles triangle being maintained.

Several limitations of this study should be noted. First, we employed a small case volume under a retrospective design. SPCH was offered for patients with CDC after March 11, 2020, and it was always the parents’ first choice,

so no multiport procedures were performed since then. Consequently, the SPCH group was compared with a historical cohort of the MPCH group. Second, the surgical management was different in different periods, which resulted in the significantly less drainage tube placement in the SPCH group due to the principle of drainage tube placement gradually changing over the years. However, the study period was only 3 years, and patient management was relatively unchanged in this period, so we believe the 2 groups are comparable. Third, long-term outcomes, including hepatolithiasis and incidence of malignancy were not evaluated in our research, as this was a relatively novel application of the single-port technique. Subsequent follow-up of these patients will continue to be carried out.

Conclusions

The modified SPCH was found to be comparative with traditional MPCH in the prospective of feasibility and safeness. With these modifications, SPCH is easier for surgeons to master; however, long-term outcomes and prospective studies are needed in future investigations.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at <https://tp.amegroups.com/article/view/10.21037/tp-22-557/rc>

Data Sharing Statement: Available at <https://tp.amegroups.com/article/view/10.21037/tp-22-557/dss>

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <https://tp.amegroups.com/article/view/10.21037/tp-22-557/coif>). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the

ethics committee of Guangzhou Women and Children's Medical Center (GWCMC) [approval No. (2022) 083A01]. Individual consent for this retrospective analysis was waived.

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