

Comparative clinical study of laparoscopic and open surgery in children with choledochal cysts

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ABSTRACT

الأهداف: لدراسة سلامة وفعالية استعمال المنظار لتكيسات قنوات المرارة بالمقارنة مع الجراحة المفتوحة حتى في مرحلة الطفولة المبكرة.

الطريقة: أجرينا دراسة بأثر رجعي من 206 مريض بتكيسات قنوات المرارة خلال الفترة من يونيو 2003م حتى مايو 2015م. ومن بين هؤلاء، خضع 104 مريض لعملية مفاغرة القناة الكبدية بالصائم (العملية المفتوحة)، و 102 مريضا عولجوا بالمنظار وفحص كبدي (عملية بالمنظار). وقد انقسم المرضى الذين خضعوا لطريقة المنظار أكثر من ذلك في 3 أعوام. كما قارنا المرضى خلال الفترة المحيطة بالجراحة ومتابعة الحالات بين الطريقتين والفئتين العمريتين.

النتائج: تم شفاء جميع المرضى دون حدوث وفيات. كان وقت العملية أطول في LP (OP: 225.4±51.0 دقيقة بالمقابل LP: 170.3±35.4 دقيقة، $p=0.000$)، ولكن فقدان الدم كان أكبر بكثير في OP (LP: 12.9±22.9 ملل بالمقابل OP: 52.7±32.4 ملل، $p=0.001$). وفي الوقت نفسه، فإن عدد الأيام إلى التغذية عن طريق الفم العادية (LP: 3.3±0.9 يوم بالمقابل OP: 4.1±0.9 يوم، $p=0.000$) ومدة المكوث بعد الجراحة في الجناح أقصر بكثير مع LP (LP: 7.5±2.7 يوم بالمقابل OP: 9.6±5.5 يوم، $p=0.001$). لم تكن هناك فروق ذات دلالة إحصائية بين جميع الاختبارات المذكورة أعلاه بين المرضى الأصغر سنا والأكبر سنا ($p>0.05$).

الخلاصة: تعدد LP آمنة وفعالة، حتى بالنسبة للأطفال الصغار. مع مزايا أقل فقدان الدم، والصدمات الصغيرة، وأقصر وقت نقاهة بعد العملية الجراحية وتحسين الشكل الخارجي، يجدر النظر في تطبيقها على نطاق واسع.

Objectives: To investigate the safety and effectiveness of laparoscopic management of choledochal cysts compared with the open approach, even in early childhood.

Methods: We conducted a retrospective study of 206 patients with choledochal cysts between June 2003 and May 2015. Of these, 104 patients underwent open cyst excision and hepaticojejunostomy (open operation [OP]) and 102 patients received laparoscopic management and hepaticojejunostomy (laparoscopic operation [LP]). The

patients who underwent a laparoscopic approach were further divided by the age of 3 years. We compared patients' perioperative and follow-up conditions between the 2 approaches and the 2 age groups.

Results: All patients were cured with no incidence of mortality. The operating time was significantly longer in the LP (OP: 225.4±51.0 min versus LP: 170.3±35.4 min, $p=0.000$), but blood loss (LP: 12.9±22.9 ml versus OP: 32.4±52.7 ml, $p=0.001$) was significantly larger in the OP. The number of days to normal oral feeding (LP: 3.3±0.9 days versus OP: 4.1±0.9 days, $p=0.000$) and postoperative stay-in-ward duration (LP: 7.5±2.7 days versus OP: 9.6±5.5 days, $p=0.001$) were significantly shorter with the LP. There were no significant differences among all of the above tests between the younger and older patients ($p>0.05$).

Conclusions: Laparoscopic operation is safe and effective, even for young children. With the advantages of less blood loss, smaller trauma, shorter postoperative recovery time, and improved cosmetic features, it is worth considering its widespread application.

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The incidence of choledochal cysts (CC) is distributed unevenly in terms of geography, with a much higher incidence in Asian countries than in western countries. Women and children are most commonly affected, and more than 60% of cases are diagnosed before the age of 10 years old.¹ So far, excision of the cyst and Roux-en-y hepaticojejunostomy are the most common treatment methods.² A laparoscopic operation has the advantages of small incisions, less trauma, less postoperative pain, and a speedy recovery, which are all generally accepted by surgeons and medical centres. With the development of finer instruments and increases in clinician experience, the challenges and difficulties encountered at the early stages of laparoscopic operation implementation have become easier to address. Currently, comparative reports on the safety of laparoscopic and open procedures mainly came from medical institutions that initiated the implementation of laparoscopic operations.^{1,3,4} However, due to the nature of CC, research on large samples of cases is limited, especially in comparisons between LP and OP approaches in pediatric patients. Our hospital started performing cyst resections with laparoscopic hepaticojejunostomy in 2008. Between 2008 and 2015, 102 children with choledochal cysts underwent laparoscopic cyst excision and hepaticojejunostomy, and 104 children were treated with open surgery and served as the control group between 2003 and 2015. We conducted a retrospective study and collected data including the demographic information of all patients, the type and size of the cysts, operative details and outcomes such as operation time, volume of blood loss, intraoperative blood transfusion, postoperative feeding of solids and postoperative hospital stay, and finally, preoperative and early postoperative complications including bile leakage, wound infection, and bile duct obstruction. Most importantly, we separated the patients in the LP group into 2 subgroups according to their age when they underwent surgery: the younger group (≤ 36 months, $n=64$) and the older group (>36 months, $n=38$). A statistical analysis was conducted to compare the aforementioned outcome variables between the 2 approaches and the 2 subgroups. The purpose of this article is to validate the safety and effectiveness of laparoscopic surgery and the feasibility of laparoscopic cyst excision and hepaticojejunostomy for younger children.

Methods. The main clinical symptoms of CC are fever, abdominalgia, jaundice, and abdominal mass. All patients diagnosed with a choledochal cyst accepted

abdominal ultrasonography and CT. Some of the patients underwent MRCP due to the long procedural time and the poor compliance of children, but intraoperative cholecystocholangiography is capable of revealing the bile duct clearly. Before the operation, an interview was conducted between the doctors and the caretakers of the children for informed consent, and the choice of surgical approach was determined by the caretakers. Then, informed consent was signed and documented. After being discharged, patients were told to return to the clinic if they developed vomiting, abdominalgia, or icterus for further evaluation and management. Follow-up visits were completed through clinic interviews and telephone interviews. The follow-up interview was arranged every month in the first 6 months, every 3-6 months afterwards, and every year until the child reached the third year (telephone interview when necessary) after being discharged. The clinic follow-up contains a series of physical examinations, blood tests and imaging (including ultrasonography, CT, and magnetic resonance cholangiopancreatography). Thirty-six cases were lost during follow-up. The mean follow-up time of the remaining 170 cases was 4.5 years, with a range of 1-10 years.

Open surgery patients. A total of 104 patients were treated with open cyst excision and hepaticojejunostomy between June 2003 and May 2015. There were 74 girls (71.2%) and 30 boys (28.8%). Their ages ranged from 27 days to 12 years with a mean of 42.4 months. Of these, 84 patients (80.8%) had type I cysts and 20 patients (19.2%) had type IV cysts. The mean cyst diameter was 42 mm (Table 1).

Laparoscopic surgery patients. A total of 102 patients were treated with laparoscopic cyst excision and hepaticojejunostomy between June 2008 and May 2015. There were 78 girls (76.5%) and 24 boys (23.5%). Ages ranged from 20 days to 13 years with a mean of 33.5 months. Eighty-five patients (83.3%) had type I cysts, and 17 (16.7%) patients had type IV cysts. The mean cyst diameter was 40 mm (Table 1).

Operation method. Open surgery. The patient lies on his or her back with the right side of the body elevated. A right subcostal incision is made through which the gallbladder and choledochal cyst are excised. The jejunum is transected at a point that is 20 cm from the ligament of Treitz, and its distal end is anastomosed with the common hepatic duct retrocolicly. Then, the intestinal anastomosis (end-to-side) is performed at a

Table 1 - Comparison of patient data and cyst characteristics between open operation (OP) and laparoscopic operation (LP) in all patients with choledochal cysts.

Characteristics	OP (n=104)	LP (n=102)
Age (m)	42.4 ± 34.2	33.5 ± 28.3
Gender (M/F)	30/74	24/78
Type of cyst (I/IV) ¹	84/20	85/17
Diameter of cyst (cm)	4.2 ± 2.6	4.0 ± 2.6

¹According to the Todani classification

point 15 cm from the hepatico-jejunum anastomosis. Interrupted sutures are used for the hepatico-jejunum anastomosis. A drainage catheter is placed around the liver portal.

Laparoscopic surgery. After the induction of general endotracheal anesthesia, the patient is placed in the supine position. A vertical incision through the umbilicus is made, and then insufflation to 8-10 mm Hg is achieved through a catheter that is later replaced with a 10-mm trocar. Three additional 5-mm trocars are inserted into the right subcostal region along the midclavicular line, the paraumbilical area of the right rectus abdomini, and the top left rectus abdomini. Under the guidance of a laparoscope (Stryker Endoscopy 1188-010-000, San Jose, CA95138, USA), the gallbladder is exteriorized out of the abdominal wall. A 38% diatrizoate meglumine solution (Compound Meglumine Diatrizoate Injection, 20 ml; 15.2 g, Shanghai Xudong Haipu Pharmaceutical Co., Ltd., China) is then infused into the gallbladder for cholecystocholangiography to determine the dilated cystic condition and to verify the existence of hepatic ductal stenosis and calculus. The gallbladder is isolated and then clipped together with the choledochal cyst. Meanwhile, the hepatic duct is excluded temporarily. Finally, a Roux-en-Y jejunojunal anastomosis is performed extracorporeally by prolapsing the jejunum through a small umbilical incision (extended to 1.5-2 cm). The jejunum is brought up to the hepatic duct via the retrocolic route. An end-to-side anastomosis between the hepatic duct and the Roux-en-Y limb is conducted laparoscopically by a continuous hand suture method. One absorbable suture is used for the hepatico-jejunum anastomosis, first at the 3 o'clock position of the common hepatic duct and then at 6 o'clock and 9 o'clock continuously for the latter wall. Then, another suture is placed in the sequence of 3, 12, and 9 o'clock for the former wall. The 2 sutures are then tied at 9 o'clock, ensuring that the diameter of the anastomosis

is longer than 1 cm. A catheter is left around the liver portal.

Data collection and analysis. For comparison between the LP and OP groups and between the 2 subgroups, electronic medical records, such as patients' case files and doctors' operation notes, provided the following data: demographic information of all patients, type and size of cyst, operative details and outcomes such as operation time, volume of blood loss, intraoperative blood transfusion, postoperative feeding of solids and postoperative hospital stay, and postoperative complications. For a descriptive analysis, the frequency or the mean and standard deviation were calculated for each variable. For other continuous variables, independent sample t-tests were applied to compare the data from the LP and OP groups and from the 2 subgroups. Their respective *p*-values and corresponding confidence intervals were provided by Statistical Package for Social Sciences Version 18.0 (SPSS Inc., Chicago, Illinois, USA). The statistical significance was set at *p*<0.05.

Results. All patients were diagnosed with CC and were treated with cyst resection and an end-to-side hepaticojejunostomy. In the comparison of the patients with CC between OP and LP, LP had a longer operative time (LP: 225.4±51.0 min versus OP: 170.3±35.4 min, *p*=0.000), less volume of blood loss (LP: 12.9±22.9 ml versus OP: 32.4±52.7 ml, *p*=0.001), shorter delayed postoperative oral feeding (LP: 3.3±0.9 days versus OP: 4.1±0.9 days, *p*=0.000) and a shorter postoperative hospital stay (LP: 7.5±2.7 days versus OP: 9.6±5.5 days, *p*=0.001). Other perioperative and postoperative details are also shown in Table 2. There were no statistical differences between the 2 subgroups under the LP approach in terms of operative time, intraoperative blood loss, delayed oral feeding, and postoperative days to discharge (Table 3).

Two patients arranged for laparoscopic surgery were converted to an open procedure in the initial stage of the laparoscopic operation. One patient was a one-month-old infant who was changed to the OP group due to a large cyst, dilatation of the intestine, and limited visible operative space in the abdominal cavity. A 6-year-old patient scheduled for laparoscopic surgery was stopped due to relatively severe inflammation at the common bile duct and the surrounding tissues and large intraoperative blood loss.

Table 2 - Comparison of operative details and outcomes between open operation (OP) and laparoscopic operation (LP) in all patients with choledochal cysts.

Operative details and outcomes	OP (n=104)	LP (n=102)	P-value
Operation time (min)	170.3 ± 35.4	225.4 ± 51.0	0.000 <0.05
Mean length of edge	10.9cm	4 ports (3.5cm in sum)	
Volume of blood loss (ml)	32.4 ± 52.7	12.9 ± 22.9	0.001 <0.05
Intraoperative blood transfusion	7	1	
Postoperative feeding solids (days)	4.1 ± 0.9	3.3 ± 0.9	0.000 <0.05
Postoperative hospital stay (days)	9.6 ± 5.5	7.5 ± 2.7	0.001 <0.05

Table 3 - Comparison of operative details and outcomes between less than 3 years and more than 3 years old in laparoscopic operation patients with choledochal cysts.

Operative details and outcomes	Under 3 years of age (n=64)	Over 3 years of age (n=38)	P-value
Operation time (min)	218.7 ± 48.3	236.2 ± 54.8	0.10>0.05
Volume of blood loss(ml)	11.9 ± 14.5	14.9 ± 33.1	0.53>0.05
Postoperative feeding solids(d)	3.33 ± 1.0	3.32 ± 0.7	0.99>0.05
Postoperative hospital stay(d)	7.5 ± 2.4	7.6 ± 3.2	0.88>0.05
Conversion to open surgery	1	1	

During postoperative hospitalization, 4 patients in the OP group experienced bile leakage. Three of these patients were managed with bile drainage and were then cured. One patient required a second operation on the Roux-en-Y anastomosis. In the LP group, one patient developed bile leakage and recovered after drainage; 2 patients had subcutaneous emphysema and recovered spontaneously; and one suffered from postoperative gastrointestinal dysfunction, with complaints of a distended abdomen and vomiting. The serious complications may be due to longer anesthesia exposure and longer pneumoperitoneum duration caused by the longer operation time. Through conservative treatment including fasting, intravenous nutrition, and abdominal physical therapy, the patient recovered in 10 days. The long-term follow-up study of the LP group identified 2 cases of cholangitis that were remedied after conservative treatment including fasting and anti-inflammatory therapy, and so forth. In the OP group, 3 patients suffered from intestinal obstructions, 2 suffered biliary strictures, and 4 patients developed cholangitis. Among these patients, one patient with an intestinal obstruction received secondary surgery due to the formation of internal hernias. The 2 patients with biliary strictures were treated with secondary Roux-en-y anastomosis in the postoperative fourth and sixth months, respectively. The remaining 6 patients were treated conservatively with fasting and transfusion therapy. They are currently still in the follow-up observation period (Table 4).

Table 4 - Complications between open operation (OP) and laparoscopic operation (LP) in the perioperative period and follow-up period.

Complications	Open operation	Laparoscopic operation
<i>Perioperative period</i>		
Bile leakage	4	1
Subcutaneous emphysema	0	2
gastrointestinal dysfunction	0	1
Wound infection	2	1
Respiratory tract infection	2	3
<i>Follow-up period</i>		
Adhesive ileus	3	0
Bile duct obstruction	2	0
Cholangitis	4	2
Reoperation	3	0

Discussion. Choledochal cysts is a very common malformation of the extrahepatic biliary ducts in children in oriental countries, with presenting symptoms of abdominal pain, jaundice, and tumors. Imaging tests such as B-mode ultrasound, CT and MRCP can assist in the diagnosis. Once diagnosed, early-stage surgeries should be performed to avoid the occurrence of severe complications such as cholangitis, pancreatitis, perforation of the cyst, and even canceration.⁵ Moreover, with the extension of the

course of disease, adhesions, chronic inflammation, and expansion of the cyst could increase operative difficulty and the occurrence of postoperative complications.⁶ Cyst opening or partial excision of the cyst with inner drainage has been excluded due to its associated postoperative complications including cholangitis, cholangiolithiasis, and canceration.⁷ Currently, the main surgical technique is cyst excision with hepatico-intestinal anastomosis including hepaticojejunostomy and hepaticoduodenostomy.⁸ The laparoscopic approach has the advantage of being minimally invasive with cosmetically enhanced recovery compared with the open approach. Cyst excision with a hepatico-intestinal anastomosis through the laparoscopic approach is a common choice in adult patients,⁹ but it is a rare option in children due to its complex nature, particularly in younger children.

The comparison between the 104 cases of OP and 102 cases of LP shows that the laparoscopic operation takes more time. Two patients who had arranged for laparoscopic surgery were converted to open surgery. However, with the development of surgical skills and experience, the risk of conversion and postoperative complications has significantly decreased. Further analysis reveals that the laparoscopic operation results in less intraoperative blood loss, less postoperative recovery time, and shorter postoperative hospital stays, which may be due to its minimally invasive nature. In the early stages of laparoscopic surgery, CCs together with bile duct strictures in the porta hepatis affected laparoscopic performance.¹⁰ With the development of technology and laparoscopic video cameras becoming smaller and clearer, laparoscopic surgery is even advantageous in curing patients with bile duct strictures in the porta hepatis or cholangiolithiasis for the following reasons. First, the porta hepatis is located relatively deeply in the body. Even though an incision can be extended to increase operative visibility in order to avoid liver injury caused by strenuous retraction, the porta hepatis will still be inadequately exposed. Therefore, cases of intraoperative hepatic duct abnormalities, left and right hepatic bile duct stenosis, and calculus are sometimes ignored, increasing the occurrence of postoperative hepatic duct obstruction or infection, which are normally diagnosed as anastomotic stenosis or refluxing cholangitis.¹¹ The laparoscopic operation is conducted through the umbilicus with the liver in a suspended position, and thus, the bile duct at the porta hepatis can be observed clearly. After the common bile duct is transected, the camera can be placed within the hepatic

duct and function as a choledochoscope to evaluate the existence of a stricture and a calculus, which do not add to the difficulty of the operation. Moreover, in terms of postoperative complications, through precise laparoscopic diagnosis, the occurrences of stenosis of the bile duct and cholangitis caused by missed diagnosis are largely reduced. Second, creating a narrow hepatic duct incision under laparoscopy, taking out a calculus, flushing the biliary tract, and enlarging the bilioenteric anastomosis become much easier.¹² The normal hepatic duct stricture is similar to the neck of a hernia sac. After the anterior wall is incised, a comparatively spacious section will turn out. If the section is too short to conduct anastomosis, dissection could be extended to the concourses of the left and right hepatic ducts to enlarge the anastomotic stoma for anastomosis. Furthermore, the laparoscope can increase visibility, that is, the closer to the operative site, the larger is the magnification. Consequently, the anastomotic stoma could be enlarged at short range during the anastomosis to avoid the occurrence of anastomotic stenosis and postoperative biliary fistula. The results demonstrating that laparoscopic surgery comes with less postoperative complications such as bile leakage, anastomosis stenosis and cholangitis further prove its efficacy.

Previous reports on the early stages of laparoscopic operations showed that laparoscopic surgery required longer operative time, had a high possibility of conversion to open surgery, and resulted in more occurrences of postoperative complications that were caused by a small abdominal space, complicated structures around the hepatic portal (the hepatic artery and the portal vein are behind the common bile duct), and the existence of abnormal blood vessels.¹³ Younger patients have higher operative risks and more postoperative complications. Sufficient preoperative preparation, including gastrointestinal decompression, cleansing enema, indwelling catheterization, and bile extraction from large cysts, could help to expose the operative field fully and enlarge the operative space, making younger patients capable of enduring laparoscopic surgery.¹⁴ Additionally, younger patients usually have larger cysts and a higher possibility of cholestasis, which could easily cause cholestatic cirrhosis.^{5,15} For older children, due to repeated inflammation of the bile duct, cyst exteriorization would injure the surrounding tissues and even cause bleeding. From the age distribution, the relatively higher incidence of complications in toddlers is noticeable (Table 5). The results indicate that the 2 subgroups did not differ in operative duration,

Table 5 - Age composition distribution for open operation (OP) and laparoscopic operation (LP) in all patients with choledochal cysts.

Operation	<12m	12-24m	24-36m	36-48m	48-60m	60-120m	>120m
OP	18	25	17	11	11	20	2
LP	27	22	15	15	12	9	2
Total	45	47	32	26	23	29	4

intraoperative blood loss or postoperative recovery ($p>0.05$), which implies that the laparoscopic operation is also safe and feasible in toddlers. Operative risks and postoperative recovery delays did not increase as the patients' age decreased. However, it should be taken into consideration that the limited space in the abdomens of younger children requires a highly skilled technique for operating laparoscopic instruments. Thus, we suggest that only surgeons with experience in both open and laparoscopic surgery in older children implement this sort of operation in younger children.

Through this study, laparoscopic choledochal cyst resection and Roux-en-Y hepaticojejunostomy can be considered as safe as open surgery. Meanwhile, this procedure can relieve patients' suffering, shorten recovery time, and provide improved cosmetic effects. However, there are several limitations of our study. The number of enrolled cases of the 2 groups is not even due to its retrospective nature. The different time intervals of enrolment of the 2 groups' of patients may impact the results even though the postoperative management and discharging indexes are the same.

Laparoscopic surgery requires precise operating skills and plenty of clinical experience. The development of the Internet and transportation, the convenience of exchanging medical practices, the opening of short-term training courses on laparoscopy and the production of operation videos³ will all make laparoscopic surgery for children easier and reduce the occurrence of postoperative complications and provide good conditions for more medical centers to conduct laparoscopic operations. Age should not be a limitation of laparoscopic surgery any longer.

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