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WJGS mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal surgery and covering a wide range of topics including biliary tract surgical procedures, biliopancreatic diversion, colectomy, esophagectomy, esophagostomy, pancreas transplantation, and pancreatectomy, *etc*.

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ORIGINAL ARTICLE

Retrospective Study

Robotic-assisted Kasai portoenterostomy for child biliary atresia

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Abstract

BACKGROUND

The Kasai procedure (KPE) is an important treatment for biliary atresia (BA), the most common cause of neonatal obstructive jaundice.

AIM

To investigate the efficacy of robotic-assisted Kasai portoenterostomy (RAKPE) in patients with BA.

METHODS

Clinical data of 10 patients with BA who underwent RAKPE at the Seventh Medical Center of the People's Liberation Army General Hospital between December 2018 and December 2021 were retrospectively analyzed. One patient underwent Open Kasai portoenterostomy (OKPE) due to intraoperative bleeding. Consequently, nine patients were included in this study. Fifty-two patients who underwent OKPE during the same period served as the control group. Preoperative and postoperative biochemical indexes, surgery-related indexes, and postoperative clearance of jaundice (CJ) were recorded and statistically analyzed.

RESULTS

RAKPE was successfully completed in all nine patients, with an average total operative time of 352.2 minutes (including intraoperative cholangiography). Milk feeding resumed on an average 9.89 days postoperatively, and the average time of drainage tube removal was 18.11 days. All patients were followed up for 6 months to 2 years. The liver function indicators and bilirubin levels in 8 patients returned to normal within 3 months after surgery. Three patients developed recurrent cholangitis after discharge, with elevated white blood cell counts, liver function indicators, and bilirubin levels, requiring hospitalization for intravenous

antibiotic treatment. The duration of cholangitis ranged from 5 to 8 months post-surgery. To date, no subsequent cases of cholangitis have occurred. All patients have normal liver function and bilirubin levels, with no intrahepatic bile duct dilatation on ultrasonography. Statistical analysis comparing these indicators with those of patients who underwent OKPE showed that the RAKPE group had longer operative times and postoperative drainage tube removal durations. However, there were no significant differences in intraoperative blood loss, postoperative oral milk intake resumption, postoperative hospital stay, or CJ at 3 months post-surgery.

CONCLUSION

RAKPE is technically feasible, safe, and effective for treating BA. Once the technique is mastered, RAKPE may achieve CJ outcomes comparable to those of OKPE.

Key Words: Biliary atresia; Jaundice; Cholangitis; Neonate; Bile duct; Bile

Core Tip: We presented the results of some patients with biliary atresia treated with Robotic-assisted Kasai portoenterostomy and discussed the technical details. The conclusion is satisfactory, and the surgical outcome is largely consistent with that of Open Kasai portoenterostomy. Robot-assisted Kasai portoenterostomy can overcome the obstacles of traditional laparoscopic surgery and is likely to be more widely applied in the future.

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INTRODUCTION

The Kasai procedure (KPE) is a key treatment for biliary atresia (BA), the most common cause of neonatal obstructive jaundice. The clearance of jaundice (CJ) rate 3 months post- surgery is the primary index for evaluating the effect of KPE. Laparoscopic Kasai portoenterostomy (LKPE) is technically challenging and remains controversial. In its early stages, LKPE was not recommended by the International Pediatric Endosurgery Group in a 2007 study due to its low CJ rate[1]. However, a later study demonstrated that LKPE was comparable to Open Kasai portoenterostomy (OKPE) in terms of CJ rate. The smaller anatomical area of the porta hepatis and overcoming the learning curve were potential factors believed to contribute to the improved CJ rate[2].

Robotic-assisted Kasai portoenterostomy (RAKPE), which allows fiber block dissection at an optimal angle, may facilitate extensive dissection at the porta hepatis, transection of shallow fibrous masses, and CJ. Herein, we present the clinical outcomes of 10 patients with BA treated with RAKPE and discuss the technical details.

MATERIALS AND METHODS

We conducted a retrospective single-center analysis of 10 patients with BA who underwent RAKPE at the Seventh Medical Center of the People's Liberation Army General Hospital between December 2018 and December 2021. One patient underwent OKPE due to intraoperative bleeding, leaving nine patients in the study group. Fifty-two patients who underwent OKPE during the same period were selected as the control group. The selection process for the surgical approach involved fully informing the parents of the child patient about the advantages and disadvantages of both surgical options, with the final decision being made by the parents themselves. Preoperative and postoperative biochemical indexes, surgery-related indexes, and postoperative complications were recorded and statistically analyzed. The details are presented in Tables 1 and 2.

This study was approved by the Ethics Committee of the Seventh Medical Center of the People's Liberation Army General Hospital. The legal guardians of the patients were fully informed and signed the informed consent form.

Surgical technique

Intraoperative cholangiography: Following general anesthesia, each patient was placed in the supine position with indwelling gastric tubes. A 8.5-mm trocar was introduced through a small incision in the umbilical ring, and a laparoscope was introduced through the trocar. A second 8-mm trocar was introduced through a small incision in the body surface projection of the gallbladder. The fundus of the gallbladder was grasped through the incision using a grasper. Cholecystography indicated non-visualization of the intrahepatic and hepatic portal bile ducts (Figure 1A). BA was confirmed, and RAKPE was performed.

Table 1 Preoperative characteristics of patients

Variables	RAKPE group (*n* = 9)	OKPE group (*n* = 52)	*P* value
Sex			0.550
Male	3	30	
Female	6	22	
Age at operation (days)	66.11 (15.037)	63.98 (15.727)	0.707
Height (cm)	57 (3.391)	57 (2.584)	1.000
Weight (kg)	5.167 (0.6144)	4.896 (0.9199)	0.280
Preoperative TBIL (μmol/L)	169 (38.7879)	184.1 (44.0634)	0.339
Preoperative DBIL(μmol/L)	124.889 (33.0471)	126.738 (31.91)	0.874
ALT (U/L)	158.78 (113.796)	149.23 (110.796)	0.813

RAKPE: Robot-assisted Kasai portoenterostomy; OKPE: Open Kasai portoenterostomy; TBIL: Total bilirubin; DBIL: Direct bilirubin; ALT: Alanine transaminase.

Table 2 Intraoperative and postoperative outcomes of patients

Variables	RAKPE group (*n* = 9)	OKPE group (*n* = 52)	*P* value
Operative time (minutes)	352.22 (18.047)	180.1 (46.752)	0.000
intraoperative bleeding (mL)	22.22 (12.528)	13.02 (13.908)	0.069
Time to milk feeding (days)	9.89 (4.014)	7.9 (2.098)	0.182
Time of drainage tube removal (days)	18.11 (3.951)	13.46 (3.878)	0.008
Postoperative hospital stay (days)	23.35 (10.972)	22 (10.701)	0.986
CJ at 3 months (%)	88.9 (8/9)	71.1 (37/52)	0.423

RAKPE: Robot-assisted Kasai portoenterostomy; OKPE: Open Kasai portoenterostomy; CJ: Clearance of jaundice.

RAKPE: First, each patient was placed in the supine position. The three-armed Da Vinci robotic system was positioned directly at the head of the bed. The trocar positions are shown in Figure 1B. An 8.5-mm trocar was used to establish carbon dioxide pneumoperitoneum at a pressure of 6-8 mmHg (1 mmHg = 0.133 kPa) and served as the camera port (C). The robotic instruments were 8 mm in diameter. Two 8-mm operation ports (R1 and R2) were placed in the right upper middle and left lower abdomen, respectively. Another 5-mm accessory port (A) was introduced at the small incision of the body surface projection of the gallbladder with the camera and instruments placed. Second, we dissociated the gallbladder, dissected the hepatoduodenal ligament and the right branch of the hepatic artery, ligated the middle hepatic artery, and exposed the portal vein. Small branches (arrows) of the portal vein (triangles) were dissected using coagulation (Figure 1C). Third, the fibrous cone at the hepatic portal was fully excised (Figure 1D). Fourth, a section of the jejunum was marked 18 cm away from the Treitz ligament. The height of the hepatic branch was retained at 25 cm. An end-to-side anastomosis was performed between the proximal jejunum of the abdominal cavity and the jejunal limb (Figure 1E). The distal jejunum was anastomosed with the porta hepatis from the transverse colon (Figure 1F). Next, a drainage tube was placed near the anastomosis. Finally, liver tissue was collected for pathological biopsy.

Follow up

The patients were followed up at 1 month, 3 months, 6 months, 9 months, and 1 year after discharge, and once every 6 months after that. The indicators included routine blood tests, liver function tests, and liver ultrasonography. Patients were readmitted to the hospital at any time for further anti-infective treatment when they suffered from fever and jaundice aggravation or if cholangitis was highly suspected.

RESULTS

Ten patients with BA underwent RAKPE, of whom one patient was converted to OKPE. The criterion for transitioning from RAKPE to OKPE was the presence of uncontrollable bleeding factors. The operation was successfully completed in nine patients, with an average total operative time of 352.2 minutes (including intraoperative cholangiography). Milk

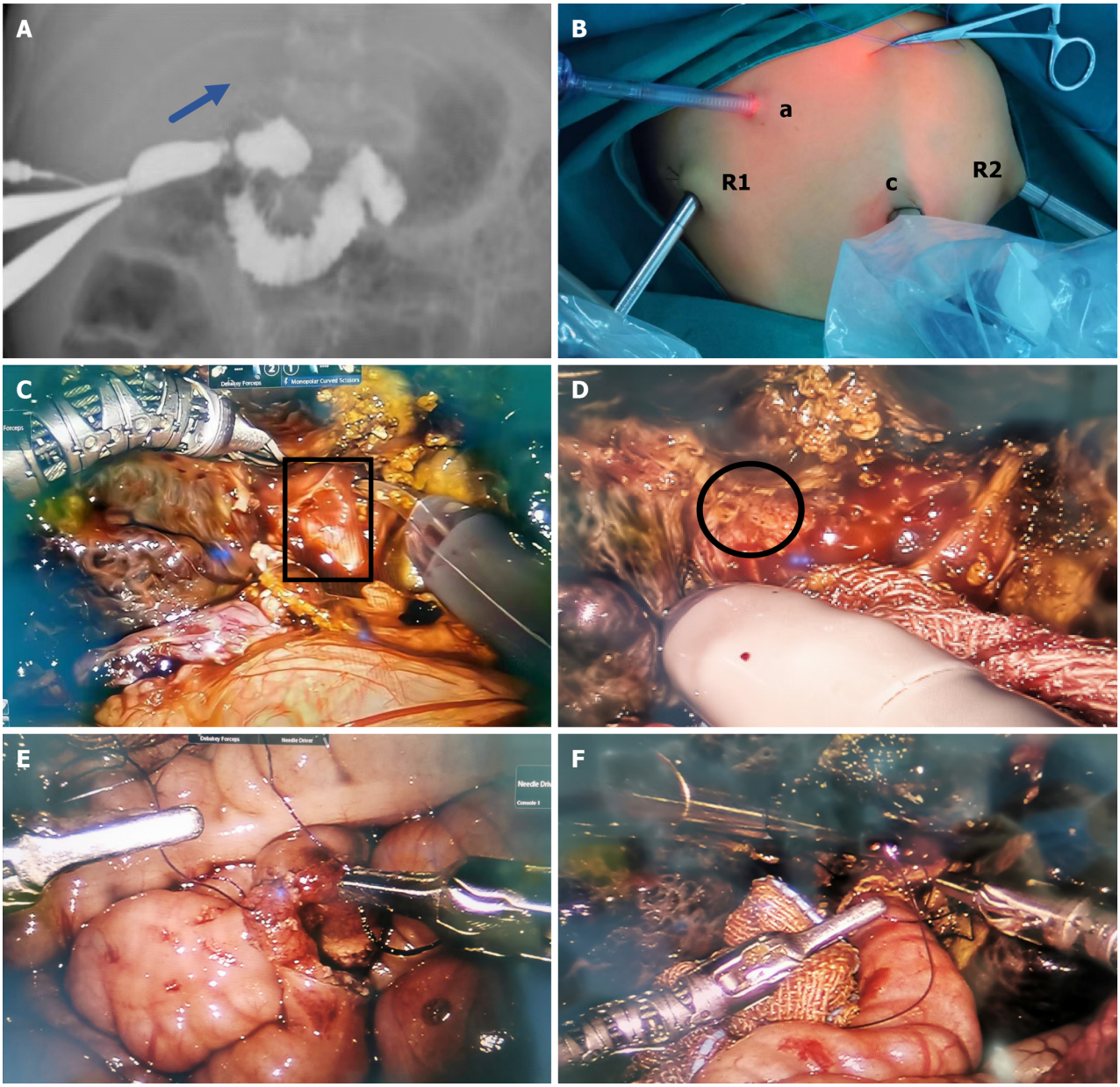

Figure 1 Intraoperative pictures. A: Laparoscopic-assisted cholangiography indicated non-visualization of the intrahepatic and hepatic portal bile ducts; B: The camera port (c, 8.5 mm), No. 1 operation port (R1, 8 mm), No. 2 operation port (R2, 8 mm), accessory port (a, 5 mm); C: Fibrous cone at the hepatic porta (black box); D: Micro-bile ducts (black circle); E: End-to-side anastomosis in the abdominal cavity; F: Anastomosis between porta hepatis and jejunum.

feeding was resumed on an average of 9.89 days post-surgery, and drainage tubes were removed on an average 18.11 days after surgery. The average postoperative hospital stay was 23.35 days. All patients were followed up for 6 months to 2 years. The liver function indicators and bilirubin levels of 8 of the 9 patients returned to normal within 3 months after surgery. Three patients developed recurrent cholangitis after discharge, and their white blood cell counts, liver function indicators, and bilirubin levels increased to varying degrees, requiring hospitalization for intravenous antibiotic treatment. These indicators were statistically analyzed and compared with those of the patients in the OKPE group, showing that the operative time and postoperative drainage tube removal time of the RAKPE group were longer than those of the OKPE group. However, intraoperative blood loss, resumption of postoperative oral milk intake, postoperative hospital stay, and CJ rate at 3 months after surgery were not significantly different.

DISCUSSION

Since the completion of the first LKPE for BA in 2002[3], few relevant studies have been published. Over the past 20 years, LKPE has been tested and opposed by some scholars[4-6]. It is generally believed that the early CJ rate achieved with LKPE is not comparable with that of OKPE. Porta hepatis dissection is relatively complex, and excessive electrocoagulation for local bleeding during laparoscopy can cause varying degrees of thermal injury to the micro-bile ducts[7].

Moreover, the limited scissor angle when excising the fibrous mass in the hepatic portal region raises questions about whether LKPE can achieve satisfactory bile drainage[8], contributing to prolonged learning curve[9]. Furthermore, the learning curve for LKPE in BA is longer due to associated morbidity. However, no clear evidence supports that LKPE results in minimal intra-abdominal adhesions during subsequent liver transplantation[5,6].

Recent studies have demonstrated that satisfactory bile drainage can be achieved without excessive dissection at the porta hepatis, with the CJ rate consistent with that achieved through extensive dissection at the porta hepatis, a prerequisite for LKPE success. In 2007, Dutta *et al*[1] reported three cases in which the da Vinci robotic system was used to perform portoenterostomy, all of which were completed without perioperative complications. The authors claimed that the da Vinci robotic system has the advantages of high definition and flexibility[1]. Meehan *et al*[2] also reported two cases treated with the da Vinci robotic system in 2007, with no perioperative complications, and jaundice resolved within 1 month after surgery. However, one patient underwent liver transplantation due to recurring bouts of cholangitis 1 year after surgery[2]. Zhang *et al*[10] conducted a single-center study on RAKPE and found that it has a good prognosis and can be used as a treatment option for BA.

Among the 10 RAKPE cases in this study, one was converted to OKPE due to intraoperative bleeding caused by the operator's inexperience, and the remaining nine patients completed the surgery. The RAKPE group had a longer operative time compared to the OKPE group because the operator was in the early stages of the learning curve and desired to ensure safety; however, no significant difference was observed in intraoperative blood loss.

The robotic-assisted technique provides new perspectives to overcome the limitations of traditional laparoscopic surgery. The advantages of RAKPE are as follows: (1) The joint of the instrument improves the freedom and flexibility of the scissors. Thus, it can dissect the hepatic portal fibrous mass at a reasonable angle to ensure the appropriate dissection depth (Figure 1C) and avoid injury to the micro-bile ducts caused by dissection that is too deep or insufficient exposure of the bile ducts caused by dissection that is too shallow; (2) excision of the fibrous mass behind the portal vein and at the left side of the hepatic hilum can achieve the same results provided by OKPE; (3) the clear 3D vision and the magnified surgical field of RAKPE aid in the management of the small blood vessels in the porta hepatis, thereby reducing the risk of bleeding due to an unclear surgical field. In addition, high-definition magnification allows visualization of microbile ducts that are difficult to detect with the naked eye during OKPE (Figure 1D), thereby minimizing injury to them; and (4) RAKPE can eliminate the fulcrum effect and effectively filter fine motion, eliminating the surgeon's natural hand tremors [2,6] and thereby achieving more accurate anatomy of the porta hepatis.

As a new technology, using simulators for training can improve surgeons' proficiency and reduce surgery time, shortening the learning curve. In this study, the requirements for the robotic operating space were high since the patients who underwent RAKPE weighed approximately 5 kg and were approximately 2 months old. We overcame this difficulty by retracting the umbilical trocar and adding a conventional 5 mm operating instrument to guarantee a smooth operation. During the operation, suspending specific organs with silk threads can also enhance the surgical space.

Because the intestinal anastomosis and the anastomosis between the porta hepatis and the jejunum were performed with robotic assistance, there is a concern of anastomotic leak. Therefore, we removed the drainage tube in the RAKPE group later than in the OKPE group; however, the postoperative hospital stay was not significantly different. The main postoperative complication of both surgical methods is cholangitis, and the treatment plan involves strengthening anti-infection measures, drawing blood cultures for drug sensitivity testing, and using antibiotics rationally. The short-term outcomes of the patients in the RAKPE group (Table 2) revealed that the CJ rates were comparable with those of the OKPE group. Thus, we believe that RAKPE can replace OKPE. Given the shorter learning curve for RAKPE and its superior ability to navigate the anatomy of the porta hepatis, the outcomes of RAKPE are expected to be better than those of conventional LKPE.

CONCLUSION

Our results demonstrate that RAKPE is a technically feasible, safe, and effective surgical treatment for BA. After crossing the learning curve, it achieved CJ rates similar to those of OKPE. However, the mid/Long-term effects and long-term survival rates of the two techniques should be investigated in prospective, large-sample studies.

FOOTNOTES

Author contributions: Xing GD and Huang LM designed the study; Xing GD, Wang XQ, Duan L and Liu G performed the research; Wang Z, Xiao YH, Xia Q and Xie HW responsible for tables and pictures; Xing GD, Shen Z and Yu ZZ wrote the manuscript.

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