

Early experience of robotic surgery for type I congenital dilatation of the bile duct

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Received: 3 November 2014 / Accepted: 17 February 2015 / Published online: 26 February 2015
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Abstract Laparoscopic surgery for this disease is not widely spread due to difficulties in its procedure. We started a laparoscopic procedure for this disease since 2011, and the robotic surgery since 2012. The aim of this study is to assess early results of these procedures. We have operated seven cases from September 2011 through December 2013. First two cases were performed by laparoscopic procedure, and following cases were done by robotically assisted surgery. Of these cases, the perioperative outcome and short-term postoperative morbidity were evaluated. Their average age was 43.6 years old (20–64 years old), and male–female ratio was 2:5. Todani classification was type 1 in all cases. The operation time was 321 min in laparoscopic cases, while 489 min in robotic surgery cases. One case of robotic surgery developed postoperative intestinal obstruction of the biliary limb, requiring laparoscopic adhesiolysis. Pancreatic fistula and anastomotic leakage have not been observed. The robotic surgery for the congenital dilatation of the bile duct is feasible and is a theoretically useful option, especially for hepatico-jejunostomy. On the other hand, the limitation of energy devices, high running cost, and time consumption remain questionable.

Keywords Congenital dilatation of the bile duct · Choledochal cyst · Laparoscopic surgery · Robotic surgery · Complication

Backgrounds

Since surgery for congenital dilatation of the bile duct requires a large abdominal laparotomy, wound-related complications such as bleeding, subcutaneous hematoma, wound infection, and incisional hernia often become a problem. Besides, since the rate of this disease is much higher in young women [1, 2], a cosmetic result would have a significant impact on their QOL. Although laparoscopic surgery for this disease has been carried out since mid 1990s [3, 4], it is not widely spread due to extraordinary difficulties of its procedure, especially of hepatico-jejunostomy which requires the precise suturing skill, and of confirmation of biliopancreatic duct junction in order to avoid remnant dilated bile duct in the pancreas which might be the cause of future malignancy.

The da Vinci surgical system (Intuitive surgical, Inc., Sunnyvale, CA, USA) is now often used for the gastric surgery or the colorectal surgery in the field of digestive surgery. However, the robotic surgery for hepato-biliary-pancreatic (HBP) surgery has been rarely reported so far [5–7]. A significant benefit of the da Vinci system is the motion stability and scaling effect, which is considered to be quite useful for such a complicated procedure requiring precise suturing technique especially in a narrow operative field.

Purposes

Therefore, we considered that the da Vinci surgical system would have benefit for the surgery of the congenital dilatation of the bile duct.

The aim of this study is to assess early results and effectiveness of these procedures.

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Methods

Patient selection

According to Todani classification [8, 9], which is the modification of Alonso-Lej classification [10], we recruited type I patients whose age were over 20 year-old, for these surgery, because the type II and III cases are quite rare, and type IV and V cases require the extra management in order to avoid postoperative intrahepatic gallstone formation. All eligible patients were examined by the MR cholangiography and endoscopic retrograde cholangiography to confirm the type of the dilatation and existence of biliopancreatic maljunction prior to surgery. Patients having previous abdominal major surgeries were excluded because of possible severe adhesions. All patients were asked to sign on the consent form approved by the institutional review board of Tohoku University Hospital.

Since both procedures were not approved and covered by the National Health Insurance System of Japan, these procedures were performed after obtaining the approval of the ethics committee of the Tohoku University Hospital, and paid by the school fund of our institute.

Operative procedure

Surgical technique of both laparoscopic and robotic surgery was based on basically the same concept: the dilated extrahepatic bile duct was excised as closer to the biliopancreatic duct junction as possible including a gallbladder, and then reconstructed with Roux-en Y hepatico-jejuno-stomy. The port site and patient cart setting in the robotic surgery are shown in the Fig. 1. Details of the procedure are as follows. A patient was placed on their back with leg split position. Under general anesthesia, five trocars were placed as mentioned above. The pneumoperitoneum was then created with the carbon dioxide gas insufflation with the pressure of 10–12 mmHg. The

surgical bed was tilted slightly to a reverse Trendelenburg position. A cholecystectomy was first carried out with Dome-down technique (Fig. 2), and then the upper side of bile duct was transected (Fig. 3). The bile duct was then retracted toward ventral side, and the intra-pancreatic bile duct was dissected with electric cautery. The biliopancreatic duct junction was confirmed with fluoroscopy in some cases, and transected by ligating the bile duct with 4-0 monofilament sutures (Fig. 4). Reconstruction was performed by Roux-en-Y hepatico-jejuno-stomy retro-colonic route with 4-0 monofilament sutures in running fashion (Fig. 5). To reduce operating time, the jejuno-jejuno-stomy was created by regular laparoscopic manner prior to docking of the patients' cart in case of the robotic surgery.

From September 2011 through December 2013, we performed two laparoscopic surgery cases and five robotic surgery cases for this disease. Of those patients, we assessed duration of operation, estimated blood loss, hospital stay, and morbidity.

Results

The age of patients was 43.6 years old (20–64 years old) in average, and male–female ratio was 2:5. All cases were classified as type I bile duct dilatation according to Todani classification. Mean diameter of the common bile duct was 19.4 mm (12–30 mm). Type of pancreaticobiliary maljunction (PBM) was classified according to new Komi classification [11]. Four cases were defined as type Ia which represents that the bile duct merges into pancreatic duct. Two cases were classified as type IIa which means that the pancreatic duct merges into the bile duct, while remaining one case was classified as type IIIc2 which is a complicated type. Of those cases, first two cases were operated by laparoscopic technique and following five cases were operated by robotic surgery (Table 1).

The operation time was 321.5 min in average in laparoscopic cases, while 488.8 min in robotic surgery cases. Estimated blood loss was 15.5 g in laparoscopic cases, and 36 g in robotic cases. Duration of hospital stay is 10 days in laparoscopic cases, and 18 days in robotic cases. Intra-operative complication occurred in one case of robotic surgery. It is laceration of the lower bile duct and this case required endoscopic naso-pancreatic drainage to prevent pancreatic fistula. Postoperative complication is found in one case of robotic surgery, which developed postoperative intestinal obstruction of the biliary limb at the site where the limb passed through the mesocolon, and required laparoscopic enlargement of the mesocolon opening. Pancreatic fistula and anastomotic leakage have not been observed. No mortality was observed (Table 1).

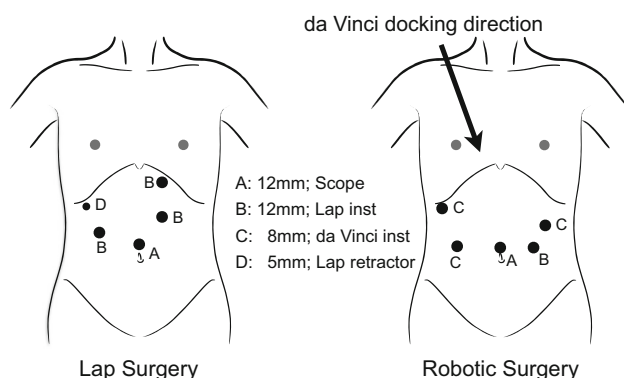


Fig. 1 Port site and docking direction

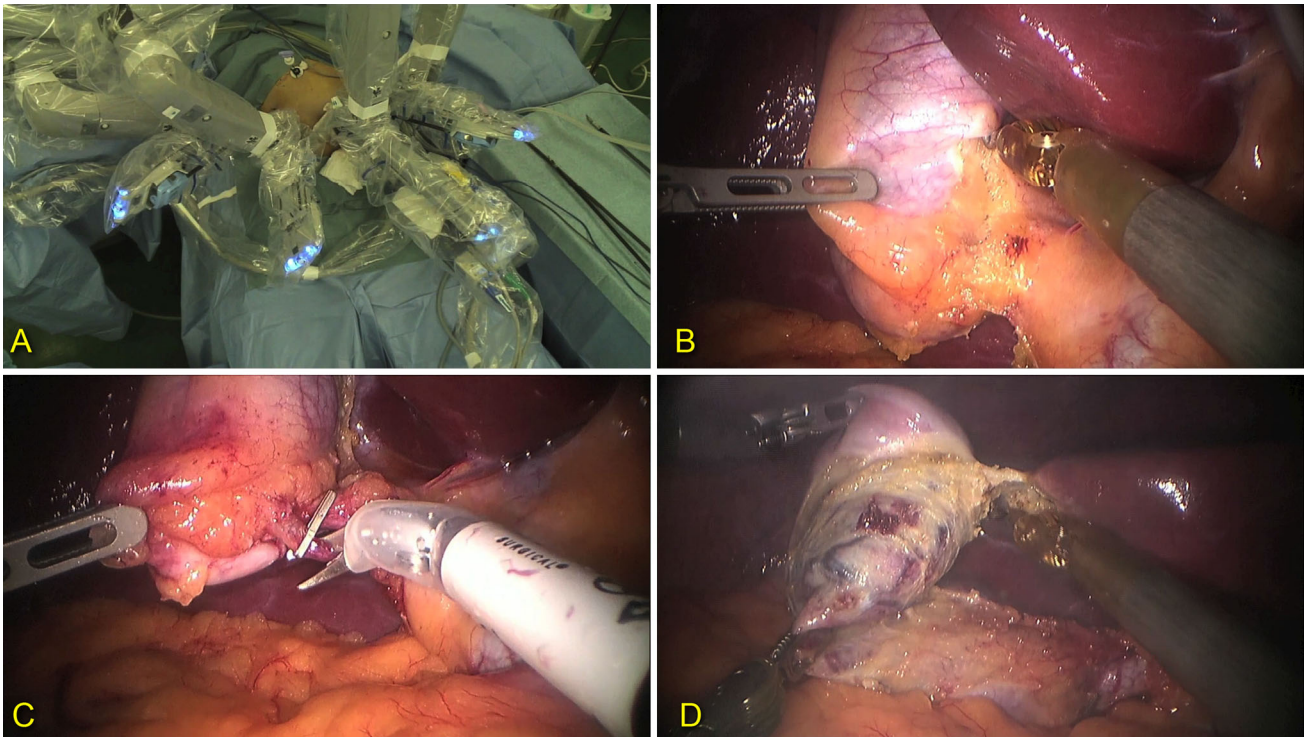


Fig. 2 a Outside view of the patient cart setting. b–d Cholecystectomy was first carried out with Dome-down technique. Electric hook cautery was mainly used for dissection

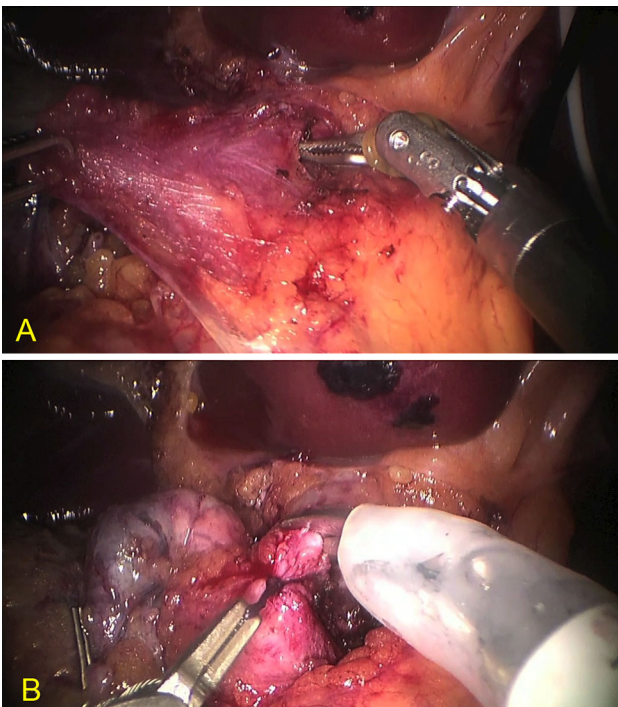


Fig. 3 a The common bile duct was dissected. b Then the hepatic side of the bile duct was ligated and transected with the scissors

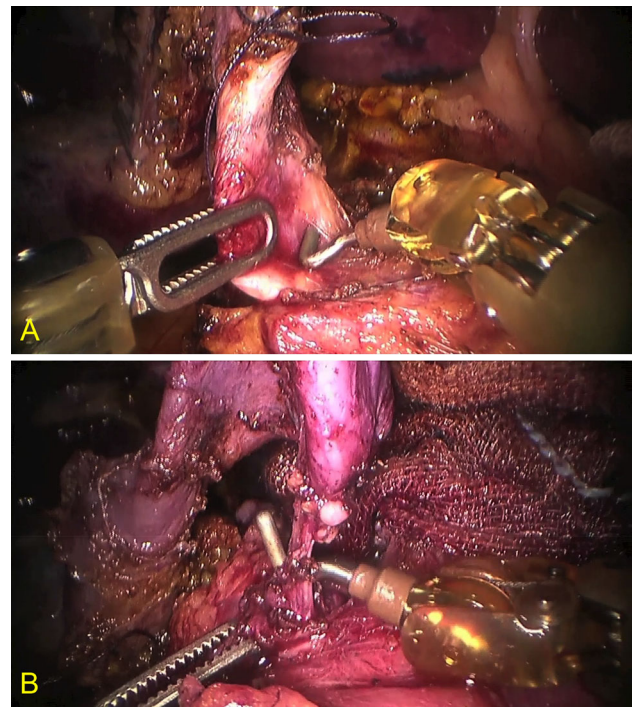


Fig. 4 a The bile duct was then retracted toward ventral side, and the intra-pancreatic bile duct was dissected with electric cautery. b The narrow segment of the lower bile duct was confirmed and transected by ligating the bile duct with 4-0 monofilament suture

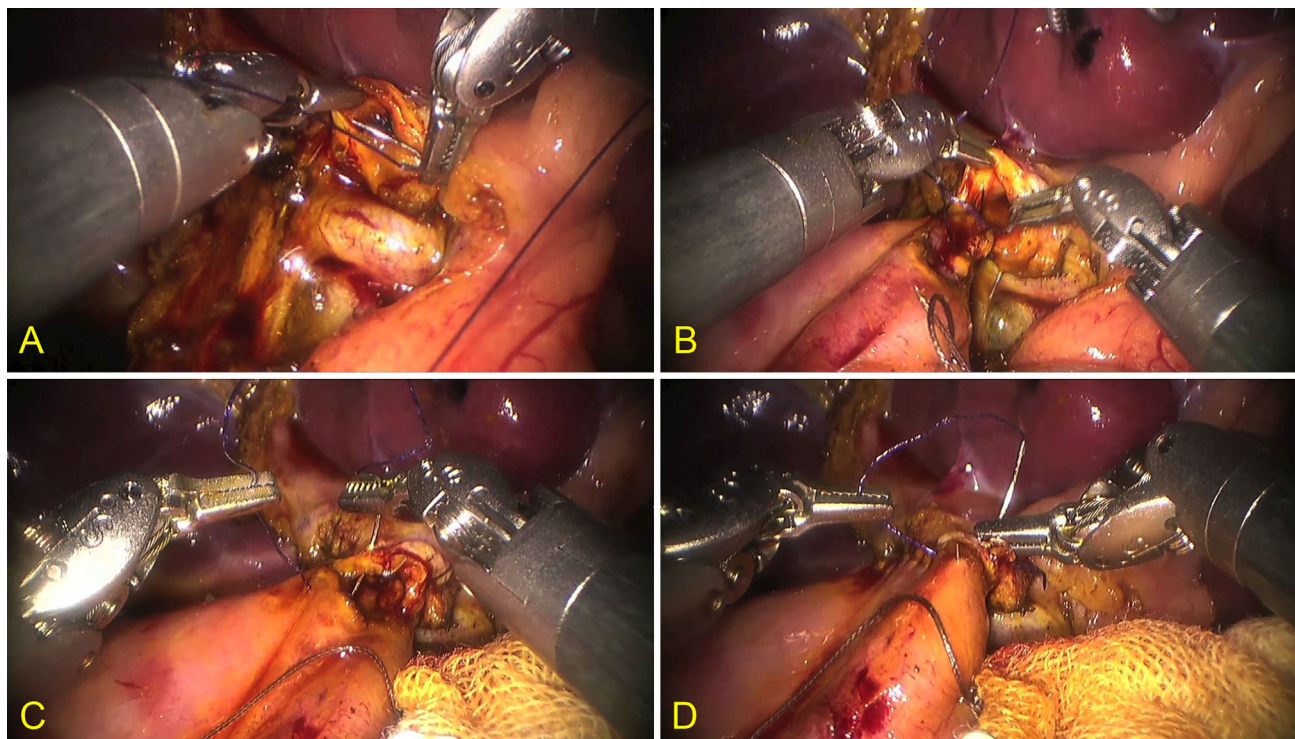


Fig. 5 Reconstruction was performed by Roux-en-Y hepatico-jejunostomy retro-colonic route with 4-0 monofilament suture in running fashion. The robotic surgery is useful for hepatico-jejunostomy in terms of motion stability and scaling effect

Table 1 Patient character and operative results

Case #	Procedure	Age	Sex	Todani class.	Max CBD Φ (mm)	PBM class.*	Op time (min)	Blood loss (min)	Complication
1	Lap	34	F	IA	20	Ia	316	6	
2	Lap	57	F	IC	10	Ia	327	25	
						Mean	321.5	15.5	
3	da Vinci	20	F	IC	12	IIa	549	10	
4	da Vinci	33	M	IA	22	IIa	506	10	Intestinal obstruction
5	da Vinci	51	M	IA	30	Ia	548	140	
6	da Vinci	64	F	IC	20	Ia	391	10	Bile duct laceration
7	da Vinci	46	F	IC	22	IIIc	450	10	
						Mean	488.8	36.0	

* New Komi classification

Discussion

Several features of endoscopic surgery including a limitation of instrument axis, a 2-dimensional image, and a lack of tactile sensation are making the endoscopic surgery complicated. These features would become barriers when mastering endoscopic surgery. In order to compensate these demerits, several basic concepts are proposed since its beginning. A co-axial setting theory, which is one of the basic concepts of port site setting, increases the ability of hand-eye coordination. A move-the-ground technique is the concept that conquers the limitation of instrument axis.

However, even by keeping mentioned concepts, there are still some challenging advanced procedures, which might be excluded from the laparoscopic surgery. The HBP surgery is one of these procedures. Although several pioneer works of experts demonstrate the feasibility of HBP surgery, the advanced laparoscopic HBP surgery other than the cholecystectomy has been the second fiddle of the gastrointestinal or bariatric surgery so far, in the field of laparoscopic surgery.

The surgery for congenital dilatation of the bile duct or choledochal cyst, which contains the resection of the extrahepatic bile duct and biliary reconstruction, is

potentially a good indication of laparoscopic surgery. The congenital dilatation of the bile duct is rare but well-known disease in eastern countries that often complicated with the biliopancreatic duct maljunction, which causes the biliary malignancies in the future. Therefore, even if it is asymptomatic, the dilated bile duct should be resected at the time of the diagnosis [1, 2]. The conventional surgery for this disease requires a large abdominal laparotomy, and wound-related complications such as bleeding, subcutaneous hematoma, wound infection, and incisional hernia often become a problem. Besides, since the rate of this disease is much higher in young women [1, 2], a cosmetic result would be a significant impact on their QOL. Therefore, the laparoscopic surgery is thought to be highly beneficial for patients having this disease. The first case of laparoscopic surgery for congenital choledochal cyst is reported by Farello et al. [3] in 1995. Tanaka et al. [4] reported small case series of this procedure in 2001. However, this procedure is still a special challenging operation and does not yet gain popularity. This is mostly due to extraordinary difficulties of its procedure, especially of biliary reconstruction. When performing regular laparoscopic surgery, the hepatico-jejunostomy requires the precise suturing skill, and this must be performed in the narrow vertical setting with an acrobatic needle driving.

The robotic surgery has been rapidly expanding in the field of urological surgery and some of the general surgery. The da Vinci surgical system is featuring multi-freedom instruments and motion stability function supporting the precise and accurate procedure. Thus we hypothesized that the da Vinci surgical system would be useful for the hepatico-jejunostomy and this operation would be the best suitable procedure for the robotic surgery.

In our series, the robotic surgery was feasible as well, though the number of cases was only five. Unfortunately, we could not present the exact data showing significant superiority of the robotic surgery at this moment. Operative time was 1.5 times as long as laparoscopic surgery. Although the learning curve of this procedure has not been reached to the plateau level, it was mostly due to the time consumption regarding the limitation of surgical devices which can be used during the robotic surgery. The limitation of surgical device is the specific problem of Japanese healthcare system. The ultrasonic coagulator, which is often used in the laparoscopic surgery has not yet been approved by the Ministry of Health, Labour and Welfare in Japan at this time. Thus we could only use the monopolar electric cautery and bipolar coagulator resulting in a relatively long operative time. To reduce the operative time, a 2-stage or hybrid robotic surgery would make sense. This is that procedure of dissecting the bile duct, at first, with regular laparoscopic manner, and then applying the robotic surgery to achieve the hepatico-jejunostomy.

Although we did not have any experiences with this hybrid robotic surgery so far, it could become a useful option. In terms of morbidity of this procedure, we have two complications in the robotic cases, intestinal obstruction of the biliary limb and laceration of the lower bile duct intraoperatively. However, these complications were not procedure related, and they could happen regardless of use of the da Vinci system. The medical cost for this surgery is the largest issue. The cost for this surgery is at least approximately 1.5 million dollars. This is covered by neither the National Health Insurance System nor the Advanced Medical Technology System in Japan. However, in the urological surgery, the surgical cost of prostatectomy is now covered by the National Health Insurance and the 70 % of the cost is paid by the insurance system. We hope that insurance system will be updated to cover this surgery in the near future.

Nevertheless, even in consideration of these disadvantages described above, the usefulness of robotic surgery deserves evaluation. Specially, the suturing maneuver can be performed easily and smoothly with the advantage of 3-dimensional vision, multi-freedom instruments, and motion stability function. In addition, the scaling effect also gives us an advantage when performing the precise suturing.

Conclusion

Therefore, we conclude that the robotic surgery for the congenital dilatation of the bile duct is feasible. Unfortunately, we could not present the definite advantage of the robotic surgery for this procedure at present. However, there are some theoretical advantages in the operation in the narrow field, especially requiring the fine suturing. The 3-dimensional vision, high motion stability, and the scaling effect would be a great benefit for the hepatico-jejunostomy, which is the most challenging procedure in this surgery.

Acknowledgments All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study. These surgeries were performed under the school fund of the Tohoku University Hospital.

Conflict of interest Takeshi Naitoh, the first author, and all co-authors declare that they have no conflict of interest.

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