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# Creation of a Robotically Assisted Terminal Jejunogastrostomy Is Safe and Effective in Regaining Antegrade Enteral Bile Duct Access After Live Donor Liver Transplant With Roux Limb

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There is a significant discrepancy between the number of patients that need liver transplants and number of organs available. In 2017, a total of 7715 orthotopic liver transplantations were performed with no significant growth in the numbers of cases performed in recent years.<sup>1</sup> Live donor liver transplantation (LDLT) has not grown significantly in the United States with only 367 cases done last year.<sup>2</sup>

Barriers to LDLT include fears of donor complications and risk of death.<sup>3</sup> In addition, LDLT is a more technically demanding operation on both the donor and the recipient ends. All aspects of reconstruction are more difficult, and in

particular, the bile duct system can be challenging. There are a number of natural variations that need to be considered. Donor safety comes first, and that means that the left duct has to be protected at all costs. Maintaining adequate arterial supply can also be very difficult. Protecting the donor usually means extensive dissection of the right hepatic artery. This means that any extrahepatic bile ducts on the right lobe are subject to ischemia. All of these factors conspire to make biliary strictures far more common in LDLT than cadaveric whole orthotopic liver transplantation.<sup>4-8</sup>

Treating posttransplant biliary anastomotic strictures can be very difficult and prolonged. Endoscopic retrograde cholangiography (ERC) is the preferred method to access such strictures as it allows most of the required maneuvers, including balloon-assisted dilation and stenting. Traditionally, there are 2 modes of biliary reconstruction during liver transplantation: duct-to-duct anastomosis (DD) and Roux-en-Y hepaticojejunostomy (HJ). Recent studies have suggested that DD is technically feasible and associated with fewer biliary complications in comparison with HJ.<sup>9,10</sup> In our case, the native bile duct was not usable for a DD at the time of transplantation due to multiple strictures.

When anastomotic strictures occur after HJ, an ERC is usually unable to be done due to the length of the Roux limb. Percutaneous transhepatic cholangiography (PTC) then becomes the next access of choice. This technique requires repeated access with external tubes, which can be life-limiting. In our particular case presentation, PTC was also unsuccessful. Surgical revision of the HJ is fraught with risks of failure, leak, recurrence, and vascular injuries. Studies have also suggested endoscopic ultrasound-guided hepaticoenterostomy (EUS-HE) as another potential therapeutic option to relieve biliary anastomotic strictures.<sup>11-13</sup> EUS-HE punctures a branch of the intrahepatic duct and subsequently places an endoprosthesis transmurally from the gastrointestinal lumen into the biliary tree to facilitate bile drainage. The potential benefits of a 1-stage procedure and having internal drainage can significantly improve patient quality of life, making EUS-HE a feasible alternative to PTC as well. However, due to aberrant biliary anatomy where 2 right hepatic ducts were anastomosed to the jejunum, EUS-HE was considered a high-risk option

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and not viable, since 2 endoprosthesis would have needed to be placed to permit adequate bile drainage.

We hypothesized that regaining endoscopic access to the hepatic ducts would help resolve the strictures efficiently and successfully in this patient through repeated ERC procedures and stenting. In our attempt to regain endoscopic access surgically, we were faced with multiple challenges. These included postoperative adhesions in the upper abdomen, risk of biliary reflux and the associated prolonged recovery, and complications after a large open operation in an immunosuppressed patient. For these reasons, we devised a minimally invasive approach using robotic-assisted surgery for this patient.

## CASE REPORT

The patient presented as a 24-year-old female with end-stage liver disease secondary to combined primary sclerosing cholangitis and autoimmune hepatitis. She was reviewed for liver transplantation and deemed an appropriate candidate. Her model for end-stage liver disease score at the time of transplant was 18. The patient's main symptoms were jaundice, pruritus, and fatigue.

The donor was a 27-year-old female presenting with aberrant biliary anatomy, where the segment 6/7 duct drained into the left hepatic duct (variation III; Figure 1).<sup>14,15</sup> This would result in right lobe graft with 2 right hepatic ducts. The arterial and portal venous anatomy were standard. The venous outflow anatomy was standard except for a large segment 8 branch that required reconstruction.

The recipient hepatectomy proceeded in the standard fashion. The portal structures were dissected beyond their primary branching points. The right hepatic vein was used for outflow at the point of entry into the inferior vena cava. The segment 8 tributary of the middle hepatic vein was reconstructed with the right hepatic vein as one anastomosis. The right portal vein was used for inflow, and the right hepatic artery was then used for arterial inflow.

The recipient bile duct was unusable due to combined primary sclerosing cholangitis and autoimmune hepatitis. We

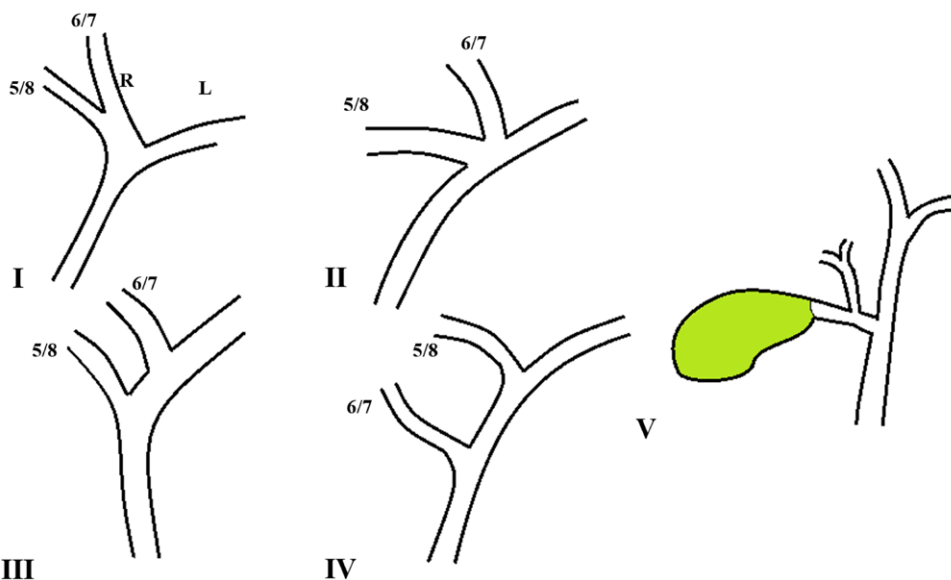
then proceeded to construct a Roux-en-Y HJ in the standard fashion. The bowel was divided about 40 cm distal to the ligament of Treitz, and a 50 cm limb was created. The limb was threaded in a retrocolic fashion. Two separate bile duct anastomoses were done using 7.0 monofilament absorbable stitches. The early postoperative course was uneventful with no vascular complications.

Less than 6 months after the transplant, the patient developed posttransplant lymphoproliferative disorder that was mainly localized to the liver. This was treated over the course of several months using rituximab and eventually eradicated about 9 months later.

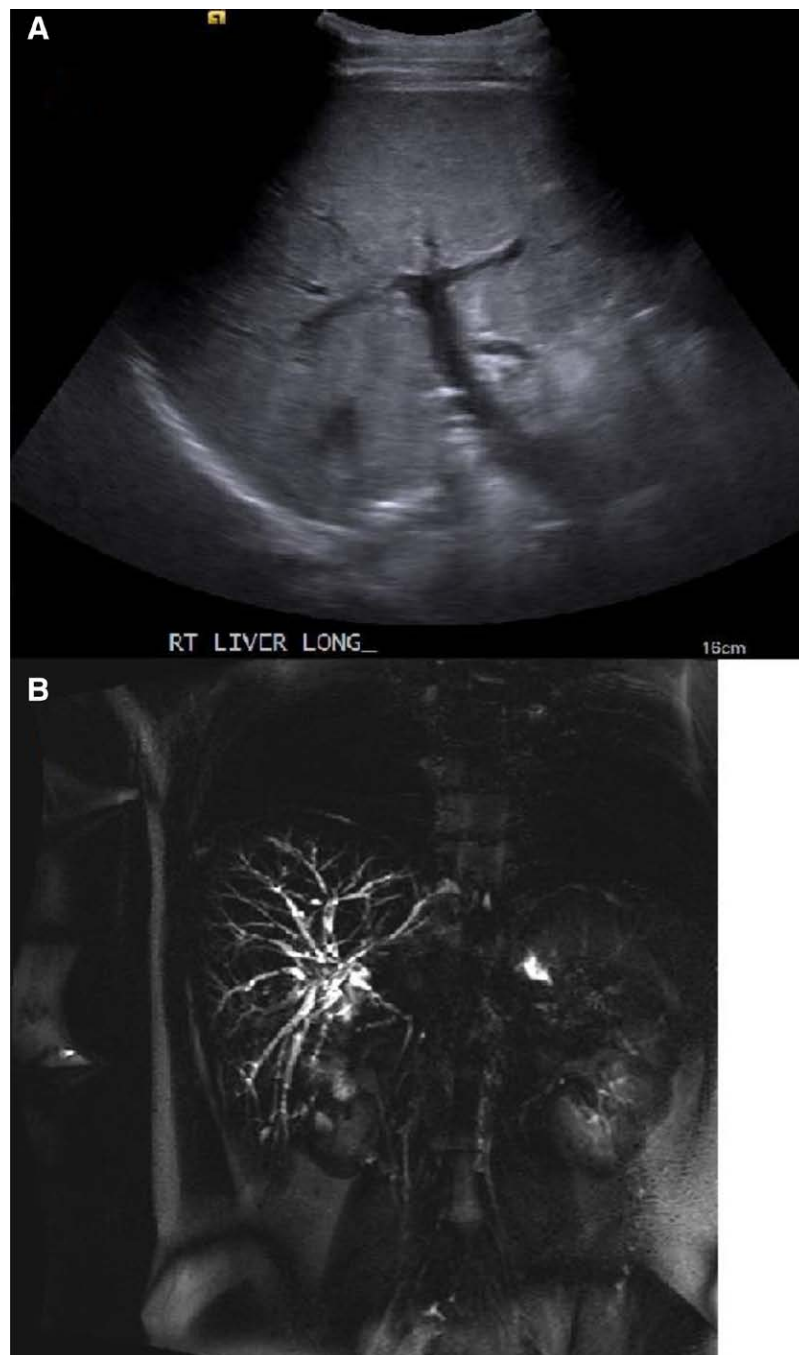
The patient started to develop progressive biliary dilation about a year after the transplant. This was observed on imaging changes (Figure 2). Eventually, she became symptomatic, and a PTC catheter was placed in only one of the ducts; at the time, a right posterior drain was not placed because there was communication and drainage via the right anterior duct (Figure 3). Balloon enteroscope-assisted ERC was attempted unsuccessfully due to the length of the Roux limb (Figure 4). Over the course of the following year, several exchanges failed to resolve the stricture. The patient had several episodes of cholangitis throughout the year.

At this point, we entertained surgical intervention. Direct revision of the anastomoses was fraught with risks of failure, leaks, and vascular complications. We entertained the idea of reestablishing direct luminal access to the Roux limb by creating a jejunogastrostomy (JG). The barriers included reentering the abdomen with an open laparotomy, biliary reflux, and all the morbidities associated with reoperation. We decided to do an antigravity competent JG using a robotic-assisted minimally invasive operation (Figure 5). An advantage of this approach was being able to enter the abdomen far from the prior operative field. This allowed us to avoid most of the upper abdominal adhesions and focus on releasing the Roux limb only. The magnification, 3-dimensional imaging, and rotilation allowed the operation to be performed with a great deal of precision.

The steps of the operations included standard robotic approach to the upper abdomen using DaVinci Xi (Intuitive



**FIGURE 1.** Conventional and common variations of right biliary anatomy.



**FIGURE 2.** Biliary dilation shown on ultrasound (A) and in MRCP (B). MRCP, magnetic resonance cholangiopancreatography.

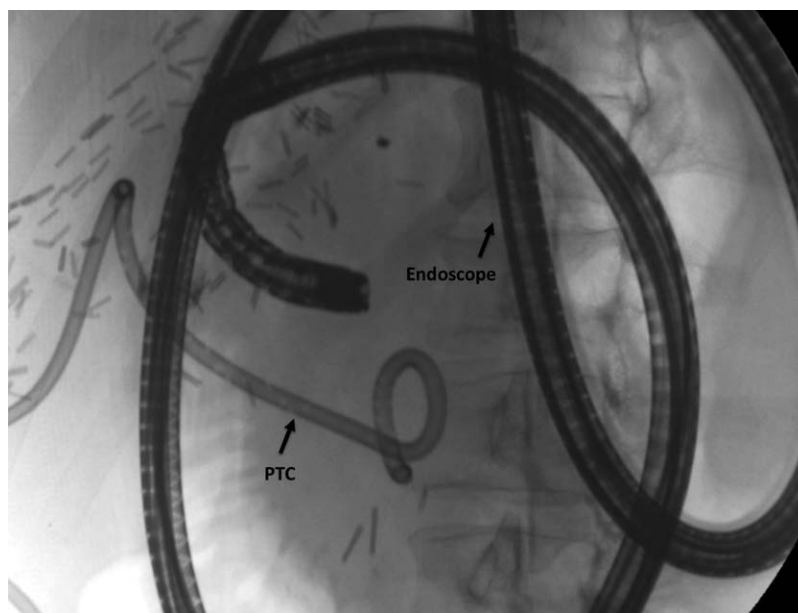
Surgical, Inc, Sunnyvale, CA). The transverse colon was dissected away from the liver, and the Roux limb was dissected leading up to the liver. The blind end of the Roux limb was then dissected free all the way to the staple line. The anterior surface of the lesser curvature of the stomach was then exposed. We then made a small 2 cm gastrotomy high on the lesser curvature of the stomach. On the Roux limb, we made a 2 cm enterotomy on the antimesenteric border. We did a hand sewn, 2-layered anastomosis that was essentially purse stringed to avoid reflux (Figure 6). We used absorbable 3.0 V-Lock stitches (Medtronic, United States). We then did an upper endoscopy to ensure the anastomosis was just wide enough to accommodate an upper endoscope. The PTC tube

was visible in the jejunum. Total docked time (time when the robotic system was utilized) was 146 minutes with an estimated blood loss of <5 mL. The patient ambulated out of bed the same day, and we were able to discharge her on a regular diet on postoperative day 3 without narcotic pain medications.

Six weeks after the operation, an ERC was easily performed; endoscopic balloon stricturoplasty and stenting were successful on both ducts. The external PTC was removed, and the stents were exchanged and removed a few weeks later (Figure 7). The patient is now asymptomatic and has no external draining PTC tubes. There were no episodes of sepsis after the endoscopic interventions started.



**FIGURE 3.** Percutaneous transhepatic cholangiography catheter placed in one of the patient's bile ducts.



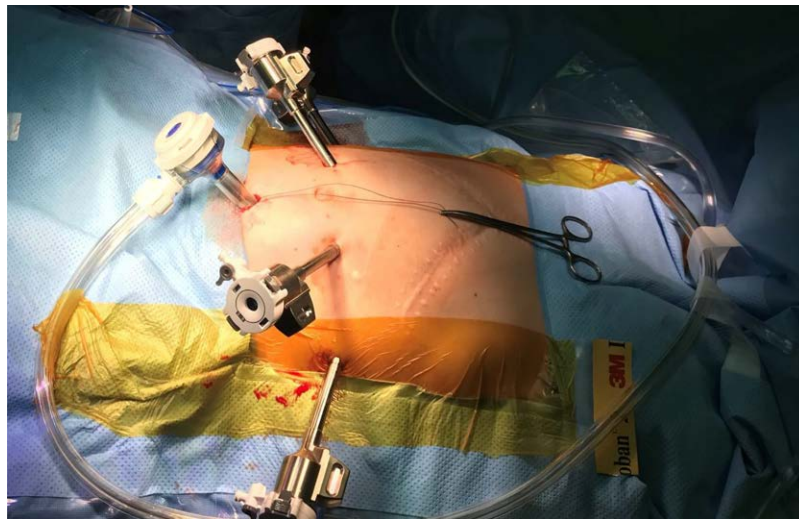
**FIGURE 4.** Unsuccessful balloon enteroscope-assisted endoscopic retrograde cholangiography due to length of the Roux limb. PTC, percutaneous transhepatic cholangiography.

## DISCUSSION

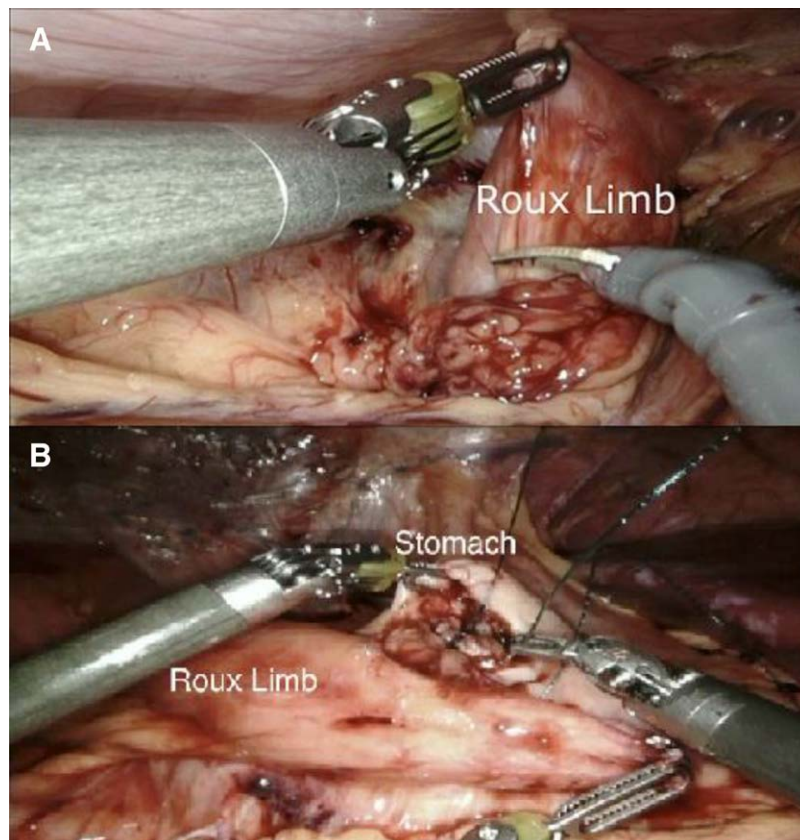
Biliary strictures are common after LDLT with a rate as high as 60%.<sup>4-8</sup> ERC remains the preferred access method to the hepatic ducts when these strictures develop. There have also been a number of studies published comparing different ways of management. Although the success rate of endoscopic interventions has proven to be superior,<sup>5,7-9,16-22</sup> endoscopic access is generally lost or becomes very difficult when Roux limbs are used. PTC catheters provide less favorable access

to these ducts.<sup>23-25</sup> When both interventions are not successful, patients are frequently left with permanent PTC tubes that need continuous maintenance and are associated with recurrent episodes of cholangitis. A number of reports have described creative endoscopic interventions to access Roux limbs.<sup>23-26</sup>

Laparoscopic or open-assisted endoscopic access has been attempted when the anatomy is altered, especially after bariatric surgery. However, this method requires repeated surgical



**FIGURE 5.** Location of trocars for robotic assistance.



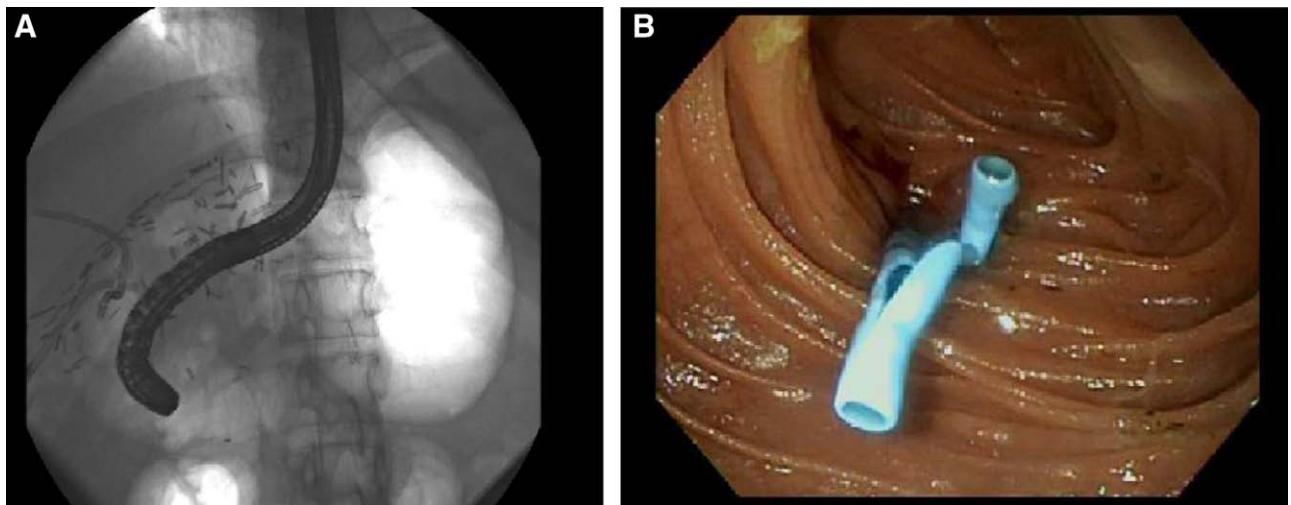
**FIGURE 6.** Identification (A) and anastomosis (B) of the Roux limb in creation of the jejunogastrostomy.

intervention, which subjects the patient to recurrent risk of complications.<sup>6,27-31</sup> The creation of a Hutson loop is another surgical alternative; however, this is another surgical intervention that requires transcutaneous access instead of the tools provided by endoscopic access.

In summary, ERC is typically the first choice in resolving biliary strictures post-LDLT with a reported success rate of 75.6% in a review of 41 patients with the average patient requiring 2.8 interventions.<sup>31</sup> PTC is the less favorable choice in resolving biliary strictures because of the morbidity of stenting—often coupled with longer time for

therapeutic efficacy and a higher number of interventions than for ERC.<sup>32</sup>

Terminal JG after Roux-en-Y HJ has been described in the context of bile duct injuries and after HJ for benign and malignant strictures (Table 1).<sup>33-36</sup> Most of these techniques were deployed in anticipation of the strictures and performed using open surgical techniques. This however has never been tried in the posttransplant setting. The challenges for this operation were reentering the operative field. Using robotics allowed us to enter the abdomen safely and far from the transplant field. The magnification and roticulating instruments allowed a safe



**FIGURE 7.** Successful endoscopic retrograde cholangiography (A) and stent placement (B) following jejunogastrostomy.

**TABLE 1.**

**Selected studies showing the efficacy of using jejunogastrostomies in different nontransplant settings**

Study	No. of patients	Success of biliary reconstruction	Comments
Ray et al <sup>33</sup>	22 patients received access-loop Roux-en-Y HJ	After a follow-up of 7 y, no recurrence of stricture was found in all 22 patients.	The end of the access loop was anchored to the subcutaneous plane, and 4 patients experienced access loop site incisional hernia.
Sitaram et al <sup>34</sup>	5	4 patients had successful dilatation of biliary strictures following the creation of a gastric access loop after initial hepaticojejunostomy.	Biliary dilatation was not possible in one patient because of a hepaticojejunostomy performed close to the mesenteric border of the jejunum.
Yan et al <sup>35</sup>	8	Of the 6 patients who received a second Roux-en-Y HJ, 5 had normal postoperative liver function without need for further intervention. One of the patients had right hepatic artery disruption requiring right hemihepatectomy.	All 8 patients had a bile duct injury from cholecystectomy, which was managed with Roux-en-Y HJ. Following the HJ, patients developed biliary strictures. Six of the 8 patients received a second Roux-en-Y HJ. Two of the 8 patients did not receive a second Roux-en-Y HJ and instead received a liver transplantation or external biliary drainage.
Jayasundara et al <sup>36</sup>	25	3 patients experienced HJ strictures which were solved by balloon sweeping or stricture dilation and stenting via the gastric access loop.	All 25 patients experienced iatrogenic bile duct injuries and received HJ either before referral or at the author's surgical center. Novel or revision HJs with gastric access loops were done at the author's surgical center.

HJ, hepaticojejunostomy.

**TABLE 2.**

**Selected studies showing the efficacy of using ERC posttransplant biliary strictures**

Study	No. of patients	Success of endoscopic intervention	Comments
Rao et al <sup>31</sup>	41	75.6% favorable response to ERC	An average of 2.8 procedures was performed on the 41 patients.
Sanada et al <sup>37</sup>	43	84% of patients had biliary strictures treated by double-balloon enteroscopy	Patients were pediatric LDLT recipients.
Tomoda et al <sup>38</sup>	20	70% of patients achieved successful endoscopic treatment of biliary strictures	All patients had received a Roux-en-Y hepaticojejunostomy during LDLT.
Koo et al <sup>39</sup>	1	Success after serial ERCs with balloon dilation of stricture	Patient demonstrated a curvilinear filling defect at the level of the choledochcholedochostomy.
Haruta et al <sup>40</sup>	1	Successful endoscopic balloon dilation	Pediatric patient 6-y posttransplantation

ERC, endoscopic retrograde cholangiography; LDLT, live donor liver transplantation.

dissection to take place. Also, a standard 2-layer anastomosis was facilitated by the augmented dexterity provided by robotic-assisted surgery.

## CONCLUSIONS

The deployment of robotic-assisted surgery can provide another method to regain luminal access to

hepaticojejunostomies when a Roux limb is used for LDLT. These instruments provide superior vision and roticulation. Reestablishing antegrade access to the HJ allows the superior ERC technique to be used to manage bile duct strictures (Table 2).<sup>31,37-40</sup> Thus, robotic-assisted JG may provide endoscopic access and should be considered as an alternative to percutaneous treatment for post-LDLT patients presenting with biliary strictures in Roux-en-Y hepaticojejunostomies. More cases need to be done to assess procedure feasibility and cost-effectiveness.

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