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Laparoscopic redo hepaticojejunostomy for children with choledochal cysts

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Abstract

Background The current study is to evaluate the long-term efficacy of laparoscopic redo hepaticojejunostomy (LRH) for children with cholecochal cysts (CDCs).

Methods Between January 2006 and January 2016, 44 CDC children who had biliary re-obstructions after primary definitive surgeries successfully underwent LRH in our hospital. The hepatic arteries were repositioned behind Roux loop. Ductoplasties and wide hepaticojejunostomies were carried out. The operative time, postoperative recovery and complications were compared with our open redo hepaticojejunostomy (ORH, $n = 16$) between October 2001 and December 2005.

Results There was no significant difference of age at surgery between two groups. Mean operative time in the LRH group was 2.32 h, which did not differ from 2.05 h in the ORH group ($p = 0.11$). Average postoperative hospital stay, resumption of full diet and duration of drainage in the LRH group were 5.47, 2.11 and 3.22 days, respectively, significantly shorter than 7.37, 3.31 and 4.50 days in our ORH group ($p < 0.001$, respectively). Median follow-up period was 48 months (1–120 months) in the LRH group and 140 months (120–170 months) in the ORH group. No recurrent biliary obstruction, cholangitis, intrahepatic stone formation or carcinoma were detected in either group. No blood transfusion was required in the LRH group, while one patient in ORH group required 3-day hemostatic treatment and blood transfusion for postoperative bleeding. In the LRH group, one patient suffered from bile leak and spontaneously cured after 7-day drainage. Two patients in the ORH group developed wound dehiscence and required surgical repairs. Overall morbidities were 2.3 % (1/44) in LRH group and significantly <18.8 % (3/16) in ORH group ($p < 0.05$). Liver function parameters normalized in both groups.

Conclusions In experienced hands, LRH does not necessarily require open surgery. Long-term results of the LRH group were comparable or even superior to those of the ORH group.

Keywords Choledochal cysts · Laparoscopic redo surgery · Postoperative biliary obstruction · Hepaticojejunostomy · Children

Recurrent biliary obstruction is one of the major postoperative complications in cholecochal cyst (CDC) children requiring surgical interventions [1–3]. Conventionally, redo hepaticojejunostomy is thought to be a contraindication for laparoscopic treatment due to adhesions, deranged anatomy and demanding techniques. However, in patients undergoing primary hepaticojejunostomies via laparoscopic approaches, open redo hepaticojejunostomies (ORH) obviates the advantages of the previous minimal invasive surgery. Even in patients undergoing primary hepaticojejunostomies via open approaches, parents are reluctant to accept delayed recovery, pain and potential

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wound complications of laparotomy in redo surgery. In addition, in more than 30 % of patients with a history of prior surgery, the bowel or other organs are directly adherent to the abdominal scar [4]. It increases the accidental injury of viscera when redo laparotomy is carried out through the primary abdominal scar.

We herewith expanded laparoscopic techniques in redo hepaticojejunostomies after 5 years accumulation of laparoscopic hepaticojejunostomies. Since 2012, we adopted single-incision laparoscopic techniques in redo hepaticojejunostomies. The current series is the first large retrospective study to assess the long-term efficacy of laparoscopic redo hepaticojejunostomy (LRH) and compare with the outcomes of our ORHs.

Materials and methods

CDC children who suffered from biliary re-obstructions after primary hepaticojejunostomies were referred to our hospital. CDC patients underwent LRHs between January 2006 and January 2016 were reviewed and compared with our control group who underwent ORHs between October 2001 and December 2005. Both LRHs and ORHs were carried out by the same surgical team. Ethics approval from the Ethics Committee of Capital Institute of Pediatrics was obtained. Written informed consents were obtained from the parents of CDC patients prior to the study.

Preoperative ultrasonographic studies, CT scan, MRCP and intraoperative cholangiograms were carried out to detect biliary system. Perioperative liver function tests were evaluated.

Before 2012, conventional LRHs were carried out. The instrument arrangements were same to conventional laparoscopic hepaticojejunostomy as previously described [5]. Since 2012, the redo procedures were carried out using single-incision laparoscopic technique. The working instrument arrangement is shown in Fig. 1. Carbon dioxide pneumoperitoneum was established at a pressure of 10 mmHg for CDC children younger than 1 year old and 12 mmHg for those older than 1 year old.

After dissection of abdominal adhesions, a 2/0 silk transabdominal suture was placed through gallbladder fossa for cephalad liver retraction to expose the hepatic hilum (Fig. 1). The second 2/0 silk (CDC children < 10 years old) or 2/0 Prolene (CDC children ≥ 10 years old) transabdominal suture was placed through the proximal common hepatic duct (CHD) to facilitate dissection and redo hepaticojejunal anastomosis (Fig. 1). In patient with enlarged left liver lobe, a 2/0 silk transabdominal retraction suture was placed through falciform ligament or a bridge of hepatic tissue connecting the two lobes and anchored at the intersection of left subcostal margin and anterior axillary line. It was helpful

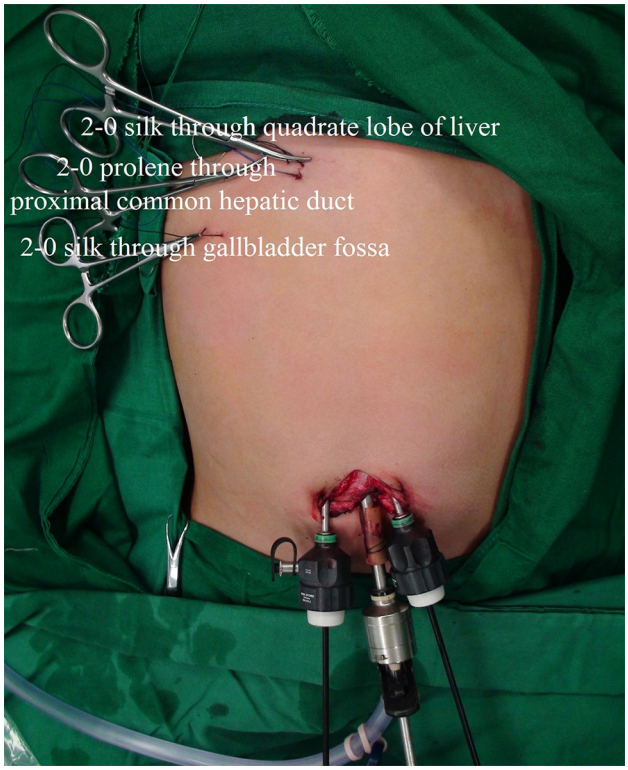

Fig. 1 Working instrument arrangement in single-incision laparoscopic redo hepaticojejunostomy. A 2- to 2.5-cm umbilical longitudinal incision is made. A 5-mm 30° laparoscope (26046BA, Karl Storz GmbH & Co. KG, Tuttlingen, Germany) is inserted through the midline of incision. Two 3-mm conventional laparoscopic instruments are inserted through the working ports which are placed each side of the camera port at the ends of horizontal umbilical incision

to expose portal vein and hepatic artery which were situated medial posteriorly. In patients with severe cirrhotic liver, an additional 2/0 silk or Prolene transabdominal retraction suture through quadrate lobe of liver was required to expose the hepatic hilum (Fig. 1). The assistant adjusted the tension and direction of suture retraction extracorporeally to facilitate dissection and anastomosis. The aberrant right hepatic artery (RHA) was carefully mobilized from the proximal CHD and repositioned behind the CHD (Fig. 2A, B, D). The stenotic segments were excised. Intrahepatic bile ducts were carefully inspected by laparoscope and irrigated by normal saline to completely remove the stones (Fig. 2C). Ductoplasties and redo hepaticojejunostomies were carried out. A drainage tube was placed.

According to the intervention protocol in our department, patients were routinely given antibiotics, glycyrrhizin and ursodeoxycholic acid postoperatively till the liver function parameters returned to normal levels.

Patients were followed up in our clinic 1, 2, 3 and 6 months postoperatively and every 6 months thereafter. The laboratory results and findings of ultrasonographic and upper gastrointestinal studies were assessed.

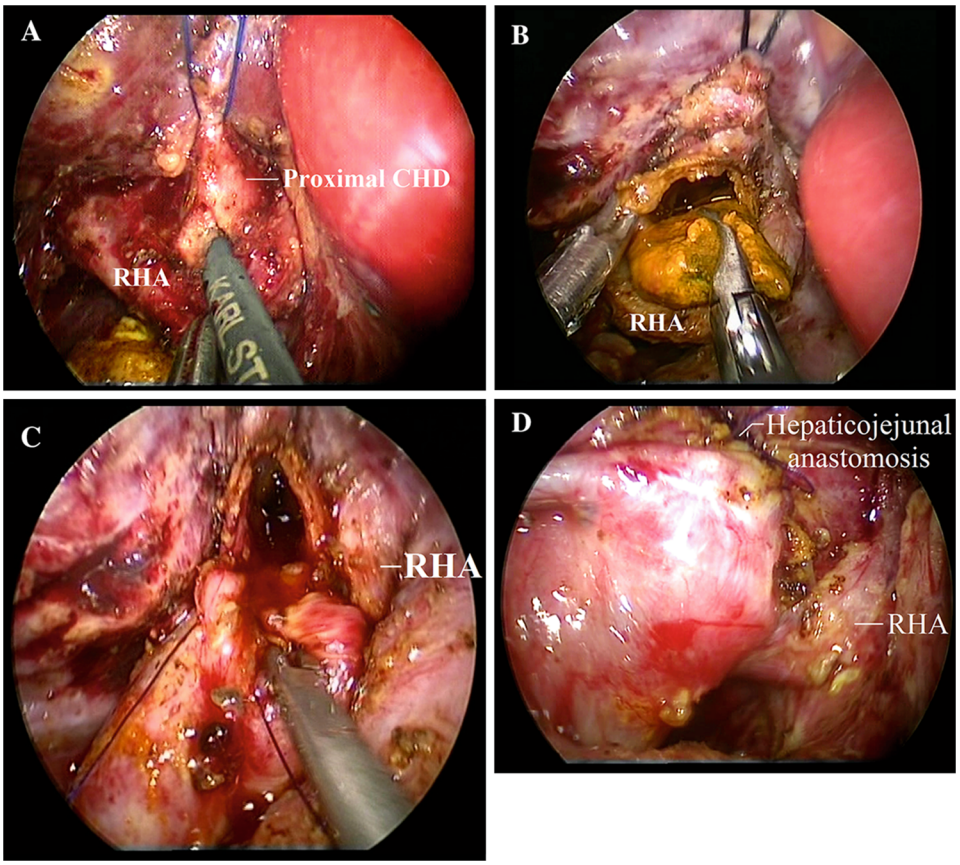

Fig. 2 Single-incision laparoscopic ductoplasty and redo hepaticojejunostomy for a 7.5-year-old girl who suffered from recurrent biliary re-obstruction because of compression of aberrant right hepatic artery (RHA) anteriorly crossing to the common hepatic duct (CHD). **A** Mobilization of aberrant right hepatic artery (RHA) from the proximal common hepatic duct (CHD). **B** Intrahepatic bile duct stone clearance. **C** Posterior wall anastomosis in laparoscopic redo hepaticojejunostomy. **D** Right hepatic artery (RHA) is repositioned posteriorly to the proximal common hepatic duct

Statistic analysis

Data were analyzed with SPSS 13.0 package. Paired *t* tests were applied to compare perioperative laboratory values in both LRH and ORH groups. Independent *t* tests were used to compare the demographic data, operative time, postoperative hospital stay, resumption of full diet, and duration of drainage between LRH and ORH groups. Chi-square tests were utilized to compare the postoperative complications between LRH and ORH groups. $p < 0.05$ was considered to be statistically significant.

Results

Forty-seven CDC patients underwent LRHs. Three patients converted to ORHs because the stenotic segments extended to the intrahepatic bile ducts, which required extensive dissections. Forty-four patients (F/M: 30/14) successfully underwent either conventional ($n = 20$) or single-incision ($n = 24$) LRHs. The primary definitive surgeries were carried out via laparoscopic approaches in 35 patients and via open approaches in the remaining nine patients.

All patients suffered from recurrent cholangitis presented as jaundice, abdominal pain, fever or continuous abnormal liver function at postoperative 2 weeks to 11 years. All patients were conservatively managed with antibiotics, glycyrrhizin to boost liver function and ursodeoxycholic acid to facilitate bile excretion for 1 week to 9 years. Of them, eight patients underwent percutaneous transhepatic biliary drainages for 1 month, and additionally four patients underwent repeated percutaneous transhepatic biliary drainages for 12–19 months (replaced the drain tube every 3 months) because medication therapy failed.

The mean diameter of stenotic segments was 0.15 cm in the LRH group, similar to 0.17 cm in the ORH group (Table 1, $p = 0.47$). The mean maximal diameter of dilated proximal hepatic duct in the LRH group was 2.03 cm, which did not differ from 2.33 cm in the ORH group (Table 1, $p = 0.19$). Intrahepatic duct stones were detected with ultrasonographic studies, CT scans, MRCP and intraoperative intrahepatic duct endoscopy in 90.9 % (40/44) of the patients. All patients showed significantly elevated serum bilirubin and abnormal liver functions (Table 4). Pathological results showed that 56.8 % (25/44) patients had grade I to IV liver fibrosis.

The aberrant RHA crosses anteriorly to the proximal CHD in a high percentage of the patients who suffered from postoperative recurrent biliary obstructions (12/44, 27.3 %). The hepatic arteries were repositioned behind

Table 1 Demographic features in choledochal cyst children undergoing laparoscopic (LRH) and open (ORH) redo hepaticojejunostomies

	LRH ($n = 44$)	ORH ($n = 16$)	p
Age at surgery (years)	6.50 ± 4.94	7.73 ± 4.63	0.38
Mean diameter of stenotic segment (cm)	0.15 ± 0.08	0.17 ± 0.09	0.47
Mean maximal diameter of dilated proximal hepatic duct (cm)	2.03 ± 0.74	2.33 ± 0.84	0.19
Mean diameter of redo hepaticojejunal anastomotic stoma (cm)	2.37 ± 0.61	2.61 ± 0.58	0.17

Roux loop during the redo hepaticojejunostomies. Of the remaining patients, 13 (29.5 %) patients had associated hepatic duct strictures and underwent ductoplasties and wide hepaticojejunostomies. Nineteen (43.2 %) patients had anastomotic strictures and underwent redo hepaticojejunostomies.

The mean age at surgery in the LRH group was 6.50 years (range 4.5 months–24 years), similar to 7.73 years in the ORH group (Table 1, $p = 0.38$). The average diameter of redo hepaticojejunal anastomotic stoma in the LRH was 2.37 cm, similar to 2.61 cm in the ORH group (Table 1, $p = 0.17$). The mean operative time in the LRH group was 2.32 h, which did not differ from 2.05 h in the ORH group (Table 2, $p = 0.11$). The average postoperative hospital stay, resumption of full diet and duration of drainage in the LRH group were 5.47, 2.11 and 3.22 days, respectively, significantly shorter than 7.37, 3.31 and 4.50 days in the ORH group (Table 2, $p < 0.001$, respectively). The median follow-up period was 48 months (1–120 months) in the LRH group and 140 months (120–170 months) in the ORH group. No mortality or morbidities of recurrent biliary obstruction, cholangitis, intrahepatic stone formation or carcinoma were observed in either group. Ultrasonographic studies showed no intrahepatic bile duct dilatations after redo hepaticojejunostomies. Postoperative gastrointestinal contrast studies demonstrated no intrahepatic reflux. No blood transfusion was required in the LRH group, while one patient in the ORH group with severe liver function damage and coagulopathy had postoperative bleeding. The hemorrhage was cured by 3-day hemostatic treatments with hemocoagulase and blood transfusions. Two patients in the ORH group with liver cirrhosis developed wound dehiscence and required surgical repairs. In contrast, none of patients in the LRH group had wound complication. In early stage of LRH practice, one patient suffered from bile leak and spontaneously cured after 7-day drainage. Overall morbidities were 2.3 % (1/44) in LRH group and significantly <18.8 % (3/16) in ORH group (Table 3, $p < 0.05$). Liver function parameters in both LRH and ORH group reversed to normal levels within postoperative 2 years (Table 4, $p < 0.001$).

Discussion

The current series is the first long-term follow-up study to evaluate the efficacy of LRH. Our outcomes demonstrated that in experienced hands, majority of redo hepaticojejunostomies can be carried out via laparoscopic approaches. The success rate is 93.6 % (44 of 47 patients). The operative time in the LRH group was similar to that in the ORH group. Postoperative recovery in the LRH group was significantly faster than that in the ORH group. Postoperative complications in the LRH group were significantly less than those in the ORH group. No carcinoma was detected from either group. The advantages of LRH include that: (1) it was less invasive; (2) the magnified view allows meticulous dissection and redo anastomosis; (3) compared to the primary surgery, the dissection and hepaticojejunal anastomosis in redo surgery were closer to the hepatic hilum. Liver fibrosis with enlarged liver lobe usually denies good visibility in the ORH. In contrast, laparoscopy with umbilicus-to-hepatic hilum direction of view provides optimal observation of portal hepatis to facilitate precise maneuver; and (4) it changes the operative approach to prevent accidental injury of viscera adherent to the abdominal scar of primary open hepaticojejunostomy.

Strategy specific for different subtypes of postoperative biliary re-obstructions

Anterior crossing RHA compressing the proximal CHD

The compression of aberrant arteries (right hepatic artery, celiac artery and gastroduodenal artery) to the proximal

Table 2 Operative time and postoperative recovery in choledochal cyst children undergoing laparoscopic (LRH) and open (ORH) redo hepaticojejunostomies

	LRH ($n = 44$)	ORH ($n = 16$)	p
Mean operative time (hours)	2.32 ± 0.58	2.05 ± 0.53	0.11
Mean postoperative hospital stay (days)	5.47 ± 1.13	7.37 ± 0.62	<0.001
Mean resumption of full diet (days)	2.11 ± 0.32	3.31 ± 0.94	<0.001
Mean duration of drainage (days)	3.22 ± 0.80	4.50 ± 1.03	<0.001

Table 3 Complications in choledochal cyst children undergoing laparoscopic (LRH) and open (ORH) redo hepaticojejunostomies

	LRH ($n = 44$)	ORH ($n = 16$)	p
Blood transfusion	0	1	<0.05
Recurrent biliary obstruction	0	0	
Bile leak	1	0	
Cholangitis	0	0	
Stone formation	0	0	
Wound dehiscence	0	2	

Table 4 Pre- versus post-liver function parameters in choledochal cyst children undergoing laparoscopic (LRH) and open (ORH) redo hepaticojejunostomies

	LRH ($n = 44$)	ORH ($n = 16$)	p
ALT (U/L)			
Ref: < 40			
Pre-operation	321.38 ± 122.98	367.36 ± 165.09	0.25
Post-operation	24.12 ± 9.12	22.86 ± 12.06	0.66
AST (U/L)			
Ref: < 40			
Pre-operation	314.76 ± 125.53	362.23 ± 179.37	0.26
Post-operation	25.79 ± 8.09	25.82 ± 10.57	0.99
ALP (U/L)			
Ref: < 400			
Pre-operation	884.87 ± 315.68	855.50 ± 286.61	0.75
Post-operation	174.41 ± 57.90	173.63 ± 60.18	0.96
GGT (U/L)			
Ref: 7–50			
Pre-operation	527.12 ± 347.53	446.46 ± 227.66	0.39
Post-operation	28.92 ± 12.74	31.62 ± 13.23	0.48
TBIL (μmol/L)			
Ref: 3.4-20			
Pre-operation	160.58 ± 48.41	154.42 ± 31.26	0.64
Post-operation	13.76 ± 5.11	12.50 ± 5.27	0.41
p (pre- vs. post-operation)	<0.001	<0.001	

NB: ALT alanine transaminase, *AST* aspartate aminotransferase, *ALP* alkaline phosphatase, *GGT* γ-glutamyl transpeptidase, *TBIL* total bilirubin

CHD has been reported as a rare congenital cause of obstructive jaundice [6, 7]. Replacing the RHA behind CHD to restore normal anatomy is advocated [8, 9]. We first verified the aberrant RHA as one of the major causes of biliary tract re-obstruction after primary hepaticojejunostomy [10]. The postoperative biliary re-obstructions in nearly 30 % patients were caused by the aberrant RHA. The high morbidity urges surgeons' cautions. The mechanism of obstruction is similar to that of unrecognized crossing vessels causing recurrent ureteropelvic junction obstruction and subsequently decreased renal function at 6–11 years after primary surgeries [11]. Repositioning the RHA posterior to the hepaticojejunal anastomosis not only restores normal anatomy, but also prevents recurrent biliary obstruction caused by RHA compression.

The images of CT scans, MRCP and ultrasonographic studies should be carefully reviewed to detect the presence of an aberrant RHA anteriorly crossing the proximal CHD. The compression stenosis usually locates in the middle of the proximal CHD rather than the site of hepaticojejunal anastomosis. During dissection process, surgeons should notice the presence of the vascular pulse proximal to the anastomotic stoma, particularly when adhesions cover the aberrant RHA and obscure the vascular pulse.

The aberrant RHA is closely adherent to the anterior wall of CHD, which increases the dissection difficulty. Pulling up the transabdominal retraction suture through proximal CHD increases the interspace between RHA and CHD. It effectively prevents RHA injury during the transposition of the CHD anterior to the aberrant RHA.

Additionally, posterior wall anastomosis is technically demanding when RHA replaced posteriorly to the CHD. In our experience, a 2-year-old CDC girl was referred to our center for postoperative hemorrhagic shock. Intraoperative findings verified the RHA injury. The suture accidentally penetrated the RHA wall during posterior wall anastomosis. The oozing was unapparent initially and ignored in the surgery. With the arterial pulse, the tearing of vascular wall aggravated and eventually caused hemorrhagic shock at postoperative day 3. Emergent surgical repair was required. In our practice, pulling up the retraction suture on the anterior wall of the proximal CHD is helpful to expose the posterior wall and repositioned RHA, and thus effectively prevents RHA injury in posterior wall anastomosis. None of our patients encountered RHA injuries.

Unrecognized hepatic duct stricture

The radiological imaging demonstrates the upstream intrahepatic bile duct dilatation far from the anastomotic sites [10]. With the updates of knowledge, single stricture of hepatic duct is gradually recognized and resolved in the primary surgeries, while the multiple strictures of common hepatic and left/right hepatic duct remain unsolved. It requires careful inspections by endoscopy. The stenotic segments should be split to the proximal dilated bile duct. A wide hepaticojejunostomy is then performed at this level.

Anastomotic stricture

The radiological studies show the biliary dilatations immediately proximal to the anastomotic sites [10]. In our series, 3 of 19 (15.8 %) patients who had anastomotic stenosis suffered from bile leaks after primary surgeries and required surgical repairs. Bile leakage, accompanied by inflammation or infection, results in edema and possibility of scarring and stenosis. Improvement of anastomotic skill, preservation of blood supply, tension-free anastomosis and adequate caliber of anastomoses (diameter in older children $\geq$1 cm, diameter in neonates $\geq$0.5 cm) [12] are crucial to minimize anastomotic stenosis. In case that the proximal CHD is not wide enough, the anterior wall of CHD can be incised longitudinally.

Strategy for laparoscopic redo hepaticojejunostomy

1. Adhesiolysis: (1) periumbilical adhesions: The telescope trocar is used to bluntly dissect the periumbilical adhesions; (2) extensive abdominal adhesions: The first working port is inserted in the patient's left side because adhesions are frequently less dense after primary hepaticojejunostomy. The adhesiolysis is carried out along "umbilicus → hepatic hilum" direction using single-hand dissection technique.
2. Exposure of surgical field: Flexible transabdominal retraction stitch placements facilitate dissection, ductoplasty and redo hepaticojejunostomy.
3. Prevention of iatrogenic injuries: Appreciation of anatomical variation and avoiding excessive dissection are advised to minimize iatrogenic injuries.
4. The conversion to open surgery is not a failure. The hybrid of laparoscopy and laparotomy maximizes the advantages of both in redo surgery.

Limitation of current study

The limitation of our study is its retrospective and non-randomized nature. A large-scale prospective randomized control study is warranted to compare the efficacy of LRH and ORH in future. The study also did not control for accumulation of knowledge and experience, i.e., the surgeons knew what to look in the redo surgeries.

In conclusion, in experienced hands, conventional and single-incision LRHs are safe and effective. The long-term results of LRH are comparable or even superior to those of ORH. LRH has the potential to be a treatment choice for CDC children with postoperative recurrence of biliary obstructions.

Disclosures Dr. Mei Diao, Prof. Long Li, and Prof. Wei Cheng declare no conflicts of interest or financial ties to disclose.

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