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The application of vascularized stomach flap to repair postoperative biliary stricture

Jianping Zeng, MD, PhD[a,*], Jing Wang, MD[b], Jiahong Dong, MD, PhD[a,*], Xiaoqiang Huang, MD[b], Hongtian Xia, MD[b], Xin Xiang, PhD[b]

Abstract

Hepaticojejunostomy, which is the "gold standard" procedure for repairing postoperative biliary strictures, predisposes patients to reflux cholangitis from loss of sphincter of Oddi. The aim of this study was to assess the sphincter-preserving biliary reconstruction approach to repair postoperative biliary stricture. An autologous vascularized stomach flap was prepared and used to repair biliary defect caused by postoperative biliary stricture. Patient clinical data were analyzed retrospectively and long-term prognosis was evaluated based on the Lillemoe standard. Twenty-eight patients who underwent surgery from 2002 to 2010 were enrolled for the study. The original surgical procedure that caused biliary stricture consisted of patients having cholecystectomy (n = 22), biliary duct exploration (n = 5), and hepatectomy (n = 1). Eighteen (64%) of the 28 patients had previous repair surgery before being admitted. Based on the Bismuth level, 7 were classified as type I, 15 as type II, and 6 as type III. The mean length of biliary defect determined preoperatively by magnetic resonance cholangiopancreatography was 1.5 cm. The surgical procedure was successfully performed for all patients with a mean operation time of 261 ± 47.8 minutes. The postoperative complication rate was 10.7%, including minor bile leak (n = 2) and pulmonary infection (n = 1). There was no perioperative deaths. Two patients were absent during follow-up, and the remaining 26 patients had a mean follow-up period of 7.5 years (61–155 months). Twenty-four patients remained healthy during the follow-up period, while 2 patients (7.7%) had sporadic recurrent cholangitis that eventually resolved spontaneously. The overall long-term outcome rate was 92.3%. None of the patients had recurrence of stricture during the follow-up period. These results suggest that biliary repair using vascularized stomach flap could reduce reflux cholangitis and offer a satisfactory long-term outcome. This procedure could be a reliable method to repair postoperative biliary stricture with limited biliary defect.

Abbreviations: ERCP = endoscopic retrograde cholangiopancreatography, HJ = hepaticojejunostomy, LC = laparoscopic cholecystectomy, MRCP = magnetic resonance cholangiopancreatography, OC = open cholecystectomy, SOD = sphincter of Oddi, VSF = vascularized stomach flap.

Keywords: bile duct repair, postoperative biliary stricture, sphincter of Oddi, vascularized stomach flap

1. Introduction

Postoperative biliary stricture is a serious and potentially devastating complication that usually occurs as a result of a technical mishap associated with cholecystectomy. During the past few decades, established surgical management include end-to-end biliary anastomosis, hepaticojejunostomy (HJ), choledochoduodenostomy, portoenterostomy, liver resection, or liver transplantation. HJ is the main procedure applied to almost all kinds of postoperative biliary stricture. HJ is utilized in more than 80% of the cases and demonstrates good outcomes.[1–4] However, the physiologic structure of the upper digestion tract and normal bile flow are altered after HJ, which may increase the incidence of duodenal ulceration, fat metabolism, and absorption dysfunction.[5,6] Furthermore, HJ causes the loss of sphincter of Oddi (SOD), which is responsible for the high occurrence of postoperative refluxing cholangitis, and is observed in10% to 30% of patient.[7,8] Refluxing cholangitis severely worsens the quality of life in patients and may lead to cholelithiasis, recurrence of anastomotic stricture, and even cholangiocarcinoma.[8,9]

An intact SOD is required for the prevention of bile duct infections, refluxing cholangitis, and even recurrence of biliary stricture. Therefore, end-to-end biliary anastomosis, which preserves the normal structure of the upper digestion tract and SOD, should be the ideal reconstruction option for postoperative biliary stricture. Unfortunately, the indication for end-to-end biliary anastomosis is limited to intraoperative detected injury of the bile duct without extensive tissue loss.[10] Otherwise, the anastomosis is prone to ischemia, bile leak, and stenosis due to high anastomotic tension. Aiming to achieve similar physiologic function as end-to-end biliary anastomosis, autologous, or allogeneic tissues, such as gallbladder flap and ligamentum teres have been used as part of the biliary wall to repair postoperative biliary stricture with extensive biliary defects. Although satisfactory outcomes have been reported in a few case studies, data from large clinical cohort studies are unavailable.[11–28]

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JZ and JW contributed equally to this work.

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[a] Department of Hepato-Pancreatic-Biliary Surgery, Tsinghua Changgung Hospital, Tsinghua University, [b] Hospital and Institute of Hepatobiliary Surgery, Chinese PLA General Hospital, Beijing, China.

[*] Correspondence: Jiahong Dong, Department of Hepato-Pancreatic-Biliary Surgery, Tsinghua Changgung Hospital, Tsinghua University, Beijing, China (e-mail dongjh301@163.com).

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2. Materials and methods

This was a retrospective analysis of a prospective database of 28 patients who underwent surgical repair with autologous vascularized stomach flap (VSF). The operation was performed by 2 surgeons from 2002 to 2010 at the Chinese PLA General Hospital, which the authors in the study were previously employed. This study protocol was reviewed and approved by ethics committee of Tsinghua Changgung Hospital (Tsinghua University).

2.1. Patient selection

Magnetic resonance cholangiopancreatography (MRCP) was performed on all patients to assess the level of biliary stricture and the length of biliary defect. The biliary stricture was classified according to the Bismuth system. Only patients with Bismuth I to III stricture were considered as candidates for surgical repair using VSF.

2.2. Surgical repair methods

The surgical procedure involved the dissection of the hilar plate and hepatoduodenal ligament. Extra-hepatic bile duct, including the proximal and distal bile duct from the stricture site, was identified and exposed (Fig. 1A). For patients with bile duct continuity, the anterior wall across the stricture segment and adjacent duct was incised longitudinally, and then the status of

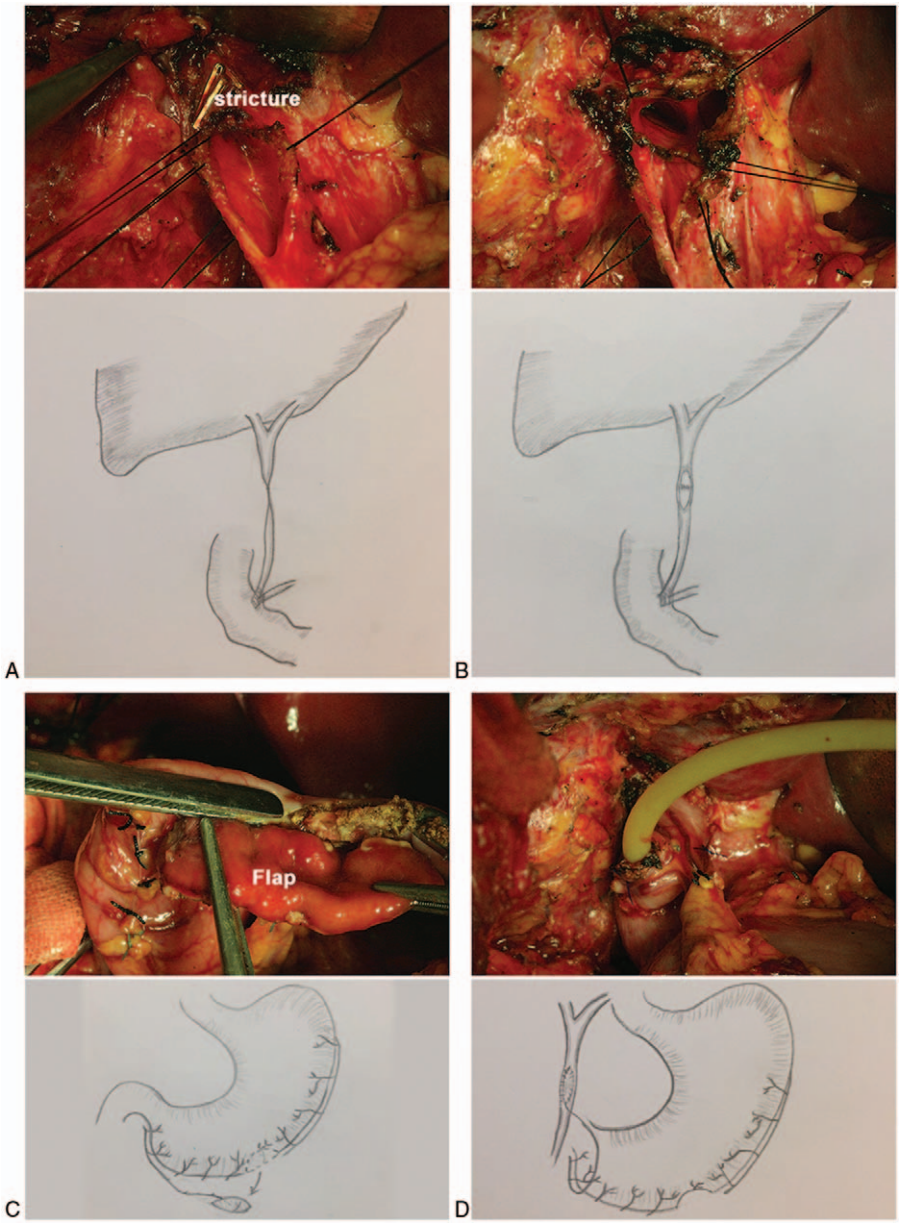

Figure 1. Surgical procedure and schematic diagram of biliary reconstruction using vascularized stomach flap. (A) The extrahepatic bile duct including the proximal and distal bile duct from the stricture site was identified and exposed, and then the stricture segment was incised. (B) After resecting the scarred tissue, the posterior wall of the bile duct was reconstructed by intermittently suture, resulting in a noncircumferential defect of the anterior wall. (C) Full thickness stomach flap was selected from the greater curvature to obtain the pedicle stomach flap. (D) Biliary defect was repaired using the stomach flap by side-to-side anastomosis, and a T tube was put through the suture site or stomach flap.

the posterior wall mucosa was evaluated. If the posterior wall mucosa was healthy, the scarred anterior wall was removed and the noncircumferential defect was repaired using vascularized pedical flap of the stomach. If the posterior wall mucosa was damaged or the bile duct was discontinued at the stricture site, the posterior wall of the bile duct was reconstructed using intermittently suture after resecting scar tissue (Fig. 1B). Afterwards, the anterior wall was repaired using VSF. Cholangioscopy was routinely performed to determine the function of SOD, and whether cholelithiasis was present in the extra- or intrahepatic bile duct. Failure to identify distal bile duct or the inability to reconstruct the posterior wall because of extensive defects, the stricture at SOD was confirmed by cholangioscopy, and HJ was performed instead of stomach flap repair.

The preparation for VSF was initiated by identification of the right gastroepiploic vessels. The stomach wall at the greater curvature supplied by large branches of right gastroepiploic vessels were selected. These vessel branches were carefully preserved and the other branches of the right gastroepiploic vessels were sequentially ligatured toward the pylorus. Full thickness of the stomach flap, which equaled the size of the bile duct defect, was incised and trimmed (Fig. 1C), and then the stomach incision was double sutured and closed. The stomach flap was positioned to the hilar plate, sutured with the bile duct wall by 4-0 or 5-0 absorbable sutures which then formed the anterior wall of the bile duct (Fig. 1D). Biliary drainage was established through the stomach flap.

2.3. Patient follow-up

All patients underwent cholangiography and cholangioscopy 4 weeks after surgery to evaluate the anastomosis status and the stomach flap. Biliary drainage was removed subsequently 1 day after cholangioscopy. The follow-up protocol included ultrasonography and liver function test every 3 months within the first year after surgery and yearly thereafter. MRCP was performed routinely at 1 year and if recurrence of stricture was suspected. Prognosis was evaluated according to the Lillemoe standard. "Excellent" was defined as no symptoms related to biliary reconstruction. "Good" was defined as mild symptoms related to biliary reconstruction but did not require invasive diagnostic or treatment procedures. "Failure" was defined as severe symptoms related to biliary reconstruction and required invasive diagnostic or treatment procedures including surgery.

3. Results

3.1. Patient characteristics

Surgical repair using VSF was performed on 28 patients. Clinical details of these patients are summarized in Table 1. The cause of biliary stricture included laparoscopic cholecystectomy (n=15), open cholecystectomy (n=7), open cholecystectomy with common bile duct exploration (n=5), and hepatectomy (n=1). Among the 28 patients, the level of obstruction to the biliary tree was classified as Bismuth I for 7 patients (25%), Bismuth II for 15 patients (53.5%), and Bismuth III for 6 patients (21.5%). The length of biliary defect was determined preoperatively by MRCP and was 1.5 cm (1.0–1.8 cm). Eighteen (64%) of the 28 patients had undergone previous definitive repair including end-to-end biliary anastomosis (n=8), bile duct suture repair (n=9), and HJ (n=1). Endoscopic treatment including balloon dilatation (n=2) and stenting (n=4) was performed in 6 patients.

Table 1

Patients' characteristics: injury cause, classification, and previous repair.

Mean age, y	**49.9±11.3**
Male/female	8/20
Injury cause	
LC	15
OC	7
Bile duct exploration	5
Hepatectomy	1
Classification	
Bismuth I	7
Bismuth II	15
Bismuth III	6
Previous repair	
No	10
End-to-end	8
Suture repair	9
Hepaticojejunostomy	1

LC = laparoscopic cholecystectomy, OC = open cholecystectomy.

3.2. Patient management

The surgical procedure was successfully performed with a mean operation time of 261±47.8 minutes (195–380 minutes). No perioperative death was recorded. Postoperative complications included minor bile leak (n=2) and pulmonary infection (n=1). All patients recovered after conservative therapy. Patients were then readmitted at 6 weeks after surgery to undergo cholangioscopy followed by cholangiography. Cholangiography showed no biliary stricture at the repair sites. Morphologic observation showed satisfactory healing between the stomach flap and bile duct wall, and smooth stomach flap surface without mucosal erosion or ulceration (Fig. 2). MRCP at 1 year after surgery showed good morphology of the extrahepatic bile duct and satisfactory shaping of the stomach flap without pouch-like expansions in these patients.

3.3. Patient outcomes

During the follow-up period, 1 patient dropped out of follow-up after 3 years and 1 patient at 5 years. Both were evaluated as excellent according to the Lillemoe standard. The rest of the 26 patients were followed-up for a mean period of 7.5 years (61–155 months). Twenty-four patients had no symptoms related to biliary reconstruction and were defined as good, while 2 (7.7%) patients had sporadic recurrent cholangitis that resolved spontaneously, and were defined as moderate. These 2 patients received endoscopic retrograde cholangiopancreatography (ERCP) and endoscopic sphincterotomy before surgery. None of the patients suffered severe cholangitis or had signs of biliary stricture based on liver function test and imaging examination. The overall excellent rate of the 28 patients was 92.3%.

4. Discussion

The SOD has multiple physiologic functions including periodical modulation of biliary pressure, control of bile secretion and pancreatic juice, and the prevention of reflux of digestive fluids.[29] The complex structure and the delicate neuromodulation mechanism of SOD makes its function vital. With the association of SOD and biliary diseases, the preservation of functional SOD during biliary surgery is crucial for maintaining

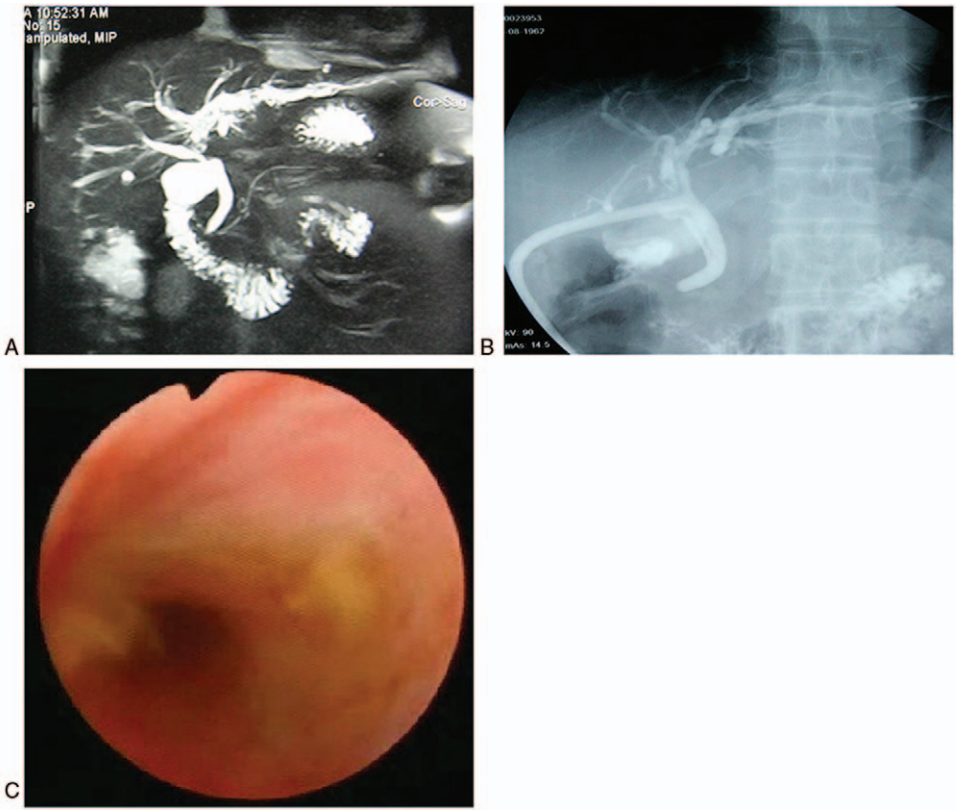

Figure 2. Cholangiography before and after stomach flap repair. (A) Magnetic resonance cholangiopancreatography displaying common bile duct stricture. (B) T-tube cholangiogram 4 weeks postoperatively showing clear bile duct. (C) Cholangioscopy displaying smooth stomach flap mucosa with no ulceration.

normal biliary physiology and function, as well as preventing recurrence of biliary diseases.

As the most common biliary reconstructive surgery, HJ is wildly applied for the surgical treatment of postoperative biliary stricture. The loss of physiologic function of SOD causes the high occurrence of refluxing cholangitis after HJ and has concerned surgeons regarding the procedure. In a retrospective study that included more than a 1000 patients suffering from different biliary-enteric procedures, the incidence of cholangitis after HJ was 6.4% and 40% of these patients suffered symptoms relating to intestinal bacterial backflow.[8] Although various anti-reflux techniques have been used to improve this procedure, none of them have been widely used due to lack of studies demonstrating their efficacy.[30–34] Compared to HJ, sphincter-preserving biliary reconstruction approach, such as end-to-end anastomosis and repair using tissue material is a promising alternative to prevent refluxing cholangitis.

Over the past few decades, several tissues or materials including ligamentum teres, umbilical vein, autologou jejunal or ileal patch, gallbladder flap, femoral vein, rectus sheath, tissue-engineered materials, and vascular prosthetic have been used to repair biliary defects, which have been reported in a few case studies or animal experiments. Stucker[11] reported that bile duct defects could be repaired using a pedicled ligamentum teres hepatis. A similar technique was introduced by Settaf and Balafrej[12] in 1993 and Chang[13] in 2000. Watanabe et al[14] used an opened umbilical vein patch for the reconstruction of an injured biliary tract in 4 patients, with no biliary stricture occurring after a follow-up period of 44 to 93 months. However, 50% of recurrence of stricture was reported by Moellmann et al,[17] where they used interposed jejunal to replace the injured biliary tract in 6 patients. The gallbladder flap was reported as a potential tissue alternative for the reconstruction of an injured bile duct in both experimental and clinical studies.[18,19]

All the above-mentioned procedures seemed efficacious, and the short- and long-term results were almost all satisfactory. However, early experience from Chinese hospitals including our own showed that the use of nondigestive tract tissue such as ligamentum teres or umbilical vein for biliary repair may lead to the high occurrence of restricture. Since these tissues could not tolerate the erosion caused by bile, they were susceptible to inflammatory necrosis and ulceration which eventually leads to repeated inflammation-repair process, fibrosis, scar contracture, and finally stenosis. However, the flap derived from the digestive tract could resist the erosion caused by bile due to mucosal protection. Cholecyst mucosa had the greatest protection against bile. However, most postoperative biliary stricture is caused by iatrogenic injury during cholecystectomy, which limits the use of gallbladder flap. The intestinal flap is easy to obtain, nevertheless, its thin wall and lack of well-formed muscle support could result in pouch-like expansion, bile stasis, cholangitis, and cholelithiasis under continuous biliary pressure. From our clinical experience, pedicle stomach flap was the ideal candidate tissue because of its excellent blood supply and resistance to bile damage. In addition, it had strong muscle support and did not tend to form pouch-like expansions under pressure. Pedicle stomach flap could be applied

for almost all cases that were suitable for autologous tissue repair due to its simple handling, adjacency to the hepatic porta, and large collection area.

In several previous studies, tubes were formed using repair tissue and then anastomosed with the bile duct using the end-to-end procedure. However, it has been demonstrated that end-to-end anastomosis is prone to stricture in animal studies.[20] In that study, the 2 experimental pigs that had a tube constructed by end-to-end anastomosis showed signs of biliary stenosis, compared to none of the 6 pigs that had a sphere constructed by end-to-side anastomosis. Using the results of that study, we reconstructed the posterior wall of bile duct, which resulted in a noncircumferential defect that was subsequently repaired by a patch with side-to-side anastomosis. This technique for reconstruction of the bile duct could reduce the anastomotic tension and avoid anastomotic stenosis. In fact, similar methods were adopted and proved to be feasible for vascular anastomosis.[35,36] The size required for VSF was determined by the defect extension of anterior bile duct wall. Several considerations, including protection of the blood supply to the stomach flap, avoidance of torsion of the vascular pedicle, and tension-free mucosa-to-mucosa anastomosis using 4-0 absorbable sutures should be considered for this procedure.

The selection procedure depends on the location of the biliary stricture, the length of the biliary defect and the function of SOD. The most important factor is whether the posterior biliary wall could be reconstructed with no tension after removal of unhealthy tissue. Stricture below a bifurcation is easier for reconstructing the posterior biliary wall compared to stricture above a bifurcation, which usually involves many branches of intrahepatic bile ducts. Hence patients with Bismuth IV or V strictures were excluded from this study. The length of biliary defect should be <2.0 cm. If it is greater, the reconstruction is unfeasible even with reducing the tension by cutting open the anterior biliary wall. Hence, strictures after suture repair for lacerated wounds or lateral wall injury could be repaired using this procedure because the posterior biliary wall was usually intact and healthy. The restricture after end-to-end anastomosis is also feasible due to limited tissue loss. However, the restricture of anastomosis after HJ is not feasible due to the contracture of the distal bile duct. In our study, only 1 patient had a previous HJ. One of the main reasons to perform autologous tissue repair instead of HJ was to preserve the function of the SOD. Hence, cholangioscopy was performed routinely during surgery in our study, while those with stricture of the SOD were excluded for autologous tissue repair.

The present study demonstrated satisfactory long-term outcomes after stomach flap to repair postoperative biliary stricture in the selected patients. Excellent shaping and gross features of the stomach flap demonstrated good compatibility between stomach mucosa and bile. During the 7.5 years mean follow-up period, only 2 patients had occasional cholangitis, which was possibly related to sphinctectomy after ERCP. This indicated the patients with sphincter relaxation secondary to sphinctectomy should be excluded from this procedure.

The HJ provides a safe and highly effective procedure for almost all types of postoperative biliary stricture.[4,37] However, sphincter-preserving biliary reconstruction should be considered as a primary treatment for preserving SOD. This may reduce or prevent sequelae in the form of cholangitis and cholangiocarcinoma. Compared with end-to-end anastomosis, which only applies to injuries detected during surgery and has no extensive tissue loss,[38,39] definitive repair using autologous VSF is more efficacious. Based on our experience, this procedure should be considered as the primary treatment option for benign strictures of the bile duct with limited tissue defects.

Author contributions

Conceptualization: Jiahong Dong.
Data curation: Jianping Zeng, Jing Wang.
Formal analysis: Jianping Zeng, Jing Wang.
Investigation: Xiaoqiang Huang, Hongtian Xia, Xin Xiang.
Methodology: Xiaoqiang Huang, Hongtian Xia, Xin Xiang.
Writing – original draft: Jianping Zeng, Jing Wang.
Writing – review & editing: Jianping Zeng, Jing Wang.

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