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AIMS AND SCOPE

The primary aim of *World Journal of Gastrointestinal Surgery* (WJGS, *World J Gastrointest Surg*) is to provide scholars and readers from various fields of gastrointestinal surgery with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

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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Retrospective Study

Initial experience with ultrafine choledochoscopy combined with low-dose atropine for the treatment of Oddi intersphincter stones

Xiao-Si Hu, Yong Wang, Hong-Tao Pan, Chao Zhu, Shuai Zhou, Shi-Lei Chen, Hui-Chun Liu, Qing Pang, Hao Jin

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Abstract

BACKGROUND

In recent years, the use of ultrafine choledochoscopy has gradually increased in the treatment of cholelithiasis. However, stone incarceration and residual spasm of the sphincter of Oddi may be inevitable when an ultrafine choledochoscope is used alone.

AIM

To investigate the safety and feasibility of ultrafine choledochoscopy combined with low-dose atropine in the treatment of Oddi intersphincter stones.

METHODS

Seventeen patients with Oddi intersphincter stones were retrospectively analyzed. The perioperative clinical data and follow-up information were collected.

RESULTS

Among the 17 patients, 3 were male and 14 were female. The mean age was 40.6 ± 13.9 years, and the mean diameter of the common bile duct was 7.8 ± 1.3 mm. All patients successfully underwent Oddi intersphincter stone removal using a combination of ultrafine choledochoscopy and low-dose atropine. No serious complications, such as postoperative hemorrhage, pancreatitis or bile leakage occurred in the 17 patients. During the one-year follow-up, none of the patients experienced stone recurrence.

CONCLUSION

Ultrafine choledochoscopy combined with low-dose atropine is safe and feasible for the treatment of Oddi intersphincter stones.

Key Words: Ultrafine choledochoscope; Atropine; Oddi intersphincter stone; Choledocholithiasis

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Core Tip: The application of ultrafine choledochoscopy has gradually been used in the treatment of cholelithiasis. However, stone incarceration with residual stones and spasm of the sphincter of Oddi may still occur. We investigated the safety and feasibility of an ultrafine choledochoscope combined with low-dose atropine for the treatment of Oddi intersphincter stones. All 17 patients successfully underwent Oddi intersphincter stone removal using a combination of ultrafine choledochoscopy and low-dose atropine. No serious complications, such as postoperative hemorrhage, pancreatitis or bile leakage occurred. None of the patients experienced stone recurrence during follow-up. Therefore, ultrafine choledochoscopy combined with low-dose atropine is safe and feasible for the treatment of Oddi intersphincter stones.

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INTRODUCTION

Choledocholithiasis is a common disease of the biliary system that can cause serious complications such as biliary obstruction, cholangitis and pancreatitis[1,2]. Oddi intersphincter stones represent a special type of choledocholithiasis that is located in the sphincter of Oddi at the terminal common bile duct. Owing to the special anatomical site, it is relatively difficult to remove Oddi intersphincter stones. Traditional treatment methods include endoscopic retrograde cholangiopancreatography combined with sphincterotomy and mechanical basket lithotomy under choledoscopy[3,4]. However, the above strategies may result in several problems, such as substantial surgical trauma, high rates of complications and incomplete stone removal[5,6].

In recent years, with the rapid progression of minimally invasive technology, the application of ultrafine choledochoscopy has gradually increased in the treatment of cholelithiasis[7]. Owing to its advantages of small diameter, flexible operation and clear field of view, the ultrafine choledochoscope can more precisely enter the Oddi intersphincter region and therefore accurately detect and remove stones. However, when used alone, the ultrafine choledochoscope may lead to stone incarceration, residual stones, and spasm of the sphincter of Oddi, which may result in surgical failure or postoperative complications.

Atropine, an anticholinergic drug, can relax smooth muscle, relieve spasm, and is widely used to treat gastrointestinal spasm. It has also been shown that atropine can relax the sphincter of Oddi[8], facilitating stone removal and improving the success rate of the operation. On the basis of the above theories and techniques, in recent years, we have innovatively applied the combination of an ultrafine choledochoscope and low-dose atropine in the treatment of Oddi intersphincter stones. In this study, we retrospectively analyzed the clinical data of 9 patients who were treated with combination therapy and explored its effectiveness and safety. This information may provide new ideas and methods for clinical treatment.

MATERIALS AND METHODS

Patients

Clinical data and surgical videos of patients with Oddi intersphincter stones admitted to the Department of Hepatopancreatobiliary, Anhui No. 2 Provincial People's Hospital from April 2021 to July 2024 were retrospectively analyzed. The inclusion criteria were as follows: (1) Aged between 18 and 75 years; (2) Terminal common bile duct stones were diagnosed using preoperative imaging, such as magnetic resonance cholangiopancreatography (Figure 1), computed tomography, and ultrasound, and Oddi intersphincter stones were further confirmed with intraoperative exploration; and (3) No obvious clinical symptoms, such as jaundice or cholangitis, were detected. The exclusion criteria were as follows: (1) Patients had serious cardiopulmonary disease, hepatic insufficiency, or renal insufficiency; (2) Patients were allergic to or contraindicated atropine; (3) Patients were pregnant or lactating; (4) Patients had uncontrolled biliary tract infection before the operation; and (5) Patients were lost to follow-up or lacked complete clinical data. Our study was reported in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Anhui No. 2 Provincial People's Hospital. All patients signed informed consent before surgery.

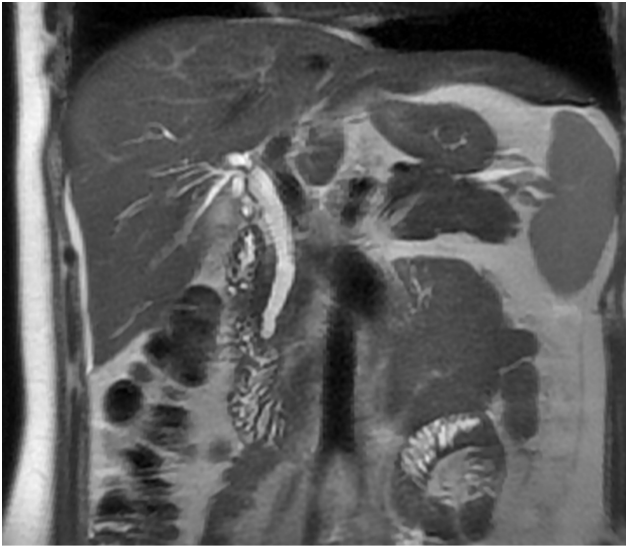


Figure 1 Magnetic resonance cholangiopancreatography showed that the stone was located in the sphincter of Oddi at the terminal common bile duct.

Equipment and materials

The ultrafine choledochoscope and related equipment were provided by Micro-Tech Co., Ltd. (host model: BS-W-150; disposable ultrafine choledochoscope model: CDS22004, diameter: 2.8 mm; disposable endoscopic lithotomy basket model: CEB01013, shape: Four-wire spiral). The amount of atropine sulfate used for injection was 0.5 mg per tablet.

Surgical procedures

Preoperative routine examinations, including routine blood tests, liver and kidney function tests, coagulation function tests and electrocardiograms, were performed. The patients were deprived of food for 4 hours and water for 2 hours before surgery. Antibiotics were administered 30 minutes before surgery to prevent infection.

General anesthesia was used, and breathing was maintained by intubation. The patients were subsequently placed in the supine position. Retrograde cholecystectomy was first performed, and the gallbladder duct was not severed. The anterior wall of the gallbladder duct was incised longitudinally at a distance of 0.5 mm from the common bile duct, and the ultrafine choledochoscope was inserted through the gallbladder duct to explore the common bile duct (Figure 2A and B). Then, under direct visual inspection using an ultrafine choledochoscope, the common bile duct was carefully examined to detect and locate Oddi intersphincter stones (Figure 2C and D). The stone was subsequently removed using a special lithotomy basket for an ultrafast choledochoscope or by being pushed into the intestinal cavity of the duodenum (Figure 2E). The common bile duct was explored once again to confirm that the stone was removed thoroughly (Figure 2F). Finally, the opening of the gallbladder duct was closed.

Before stone removal, 0.5 mg of atropine was administered intravenously, and relaxation of the Oddi sphincter was observed. If necessary, the dose was increased by 0.5 mg, and the maximum dose was 1.0 mg.

Postoperative management

The vital signs of patients were routinely observed after the operation, with special attention given to changes in breathing and heart rate. The patients were deprived of food and water for 6 hours after the operation and then gradually resumed a normal diet. Antibiotics were used continually to prevent infection. Low-dose dexamethasone (5 mg) and 654-2 (10 mg) were used in combination for 3 days. Routine blood, liver function and imaging results were reexamined at 3 days postsurgery.

Outcome indicators

The criteria for surgical success were defined as complete removal of Oddi intersphincter stone, an unblocked biliary tract, and no serious complications. The operation time was defined as the total time from the insertion of an ultrafine choledochoscope into the common bile duct to the confirmation of stone removal. Postoperative bleeding, cholangitis, pancreatitis, bile leakage, and other complications were recorded within 30 days. Patients were followed up by outpatient and telephone visits at 1, 3, 6 and 12 months after surgery. Symptom remission, stone recurrence and complications were recorded.

Statistical analysis

The Shapiro-Wilk test for normality was performed on all the data using SPSS 26.0 software. The normally distributed data are expressed as the mean \pm SD. The nonnormally distributed data are expressed as the median (minimum-maximum). The categorical data are expressed as the number of cases.

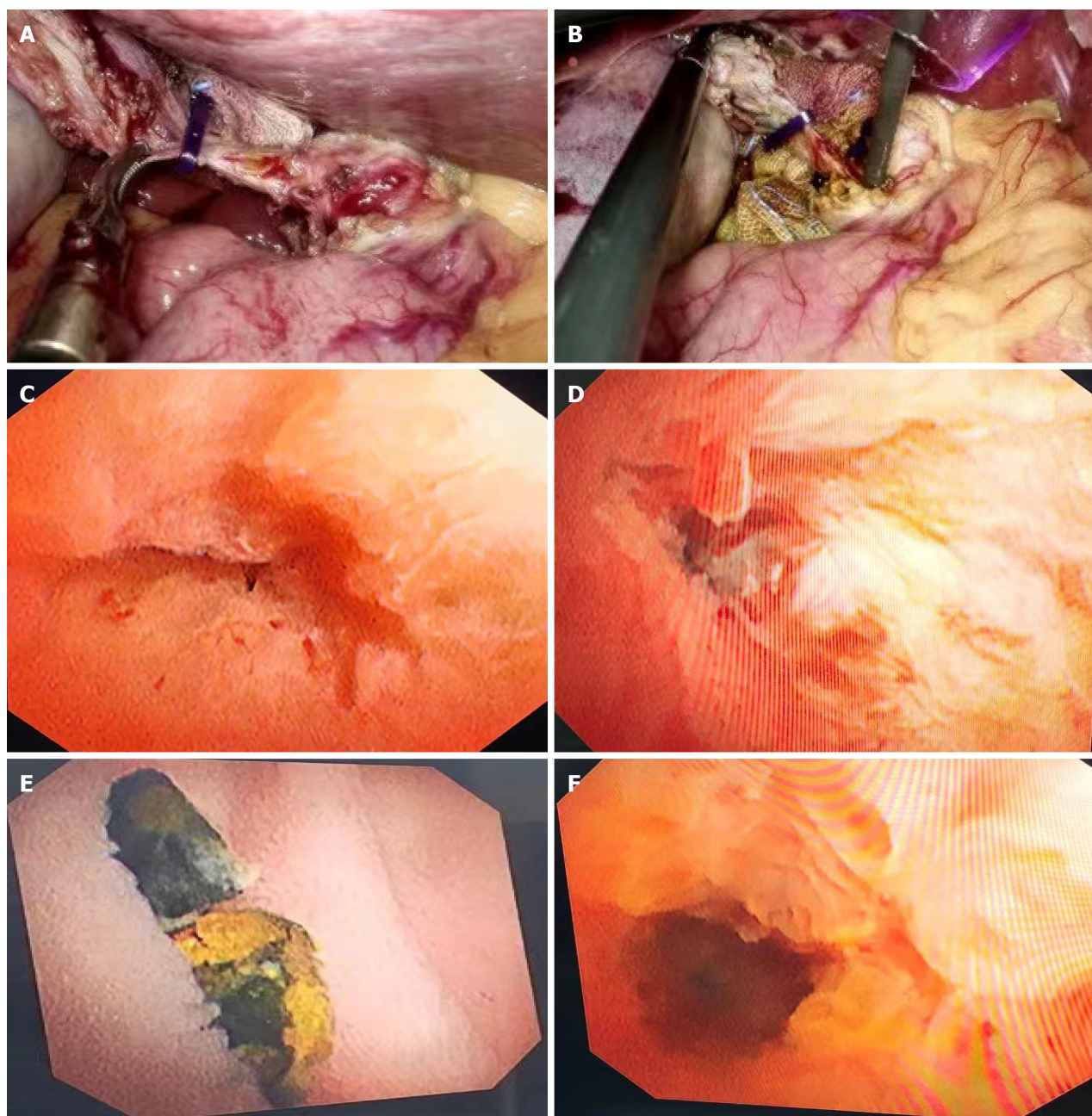


Figure 2 The process of Oddi intersphincter stone removal by ultrafine choledochoscopy combined with low-dose atropine through the gallbladder duct. A: After retrograde cholecystectomy, the anterior wall of the gallbladder duct was cut longitudinal at 0.5 mm from the common bile duct; B: Ultrafine choledochoscopy was inserted through the gallbladder duct to explore the common bile duct; C: Routine exploration of common bile duct to the terminal sphincter of Oddi showed no residual stone; D: The ultrafine choledochoscopy entered into the sphincter of Oddi, and the stones were embedded in the lower zone; E: By using atropine, the stones were pushed into the intestinal cavity; F: The surgical field of relaxation of Oddi sphincter after stone removal.

RESULTS

Basic patient information

A total of 17 patients were recruited, including 3 males and 14 females. The mean age of the patients was 40.6 ± 13.9 years, and the mean BMI was 22.1 ± 2.8 kg/m². The mean diameters of the common bile duct and gallbladder duct were 7.8 ± 1.3 mm and 3.8 ± 0.4 mm, respectively. The median maximum diameter of choledocholithiasis was 3 (2–5) mm, and 2 patients had multiple bile duct stones. The median preoperative TBIL level was 18 (8–51) μ mol/L, and 10 patients had elevated TBIL levels. All the patients had varying degrees of symptoms, such as biliary colic, jaundice and fever. The basic information of the included patients is shown in Table 1.

Operation success rate

The stones were removed successfully in all 17 patients, with a surgical success rate of 100%. Among these patients, 12 were successfully removed through the lithotomy basket using a combination of ultrafine choledochoscopy and low-dose

Table 1 Basic information of patients, mean \pm SD/median (minimum-maximum)

| Variables | Total |
|--|-----------------|
| Gender (male/female) | 3/14 |
| Age (years) | 40.6 \pm 13.9 |
| BMI (kg/m ²) | 22.1 \pm 2.8 |
| Hypertension (yes/no) | 4/13 |
| Diabetes (yes/no) | 5/12 |
| Common bile duct diameter (mm) | 7.8 \pm 1.3 |
| Gallbladder duct diameter (mm) | 3.8 \pm 0.4 |
| Maximum diameter of choledocholithiasis (mm) | 5 (1-7) |
| Number of bile duct stones (single/multiple) | 12/5 |
| ALT (U/L) | 61 (10-447) |
| AST (U/L) | 49 (13-800) |
| ALP (U/L) | 76 (42-339) |
| GGT (U/L) | 246 (9-627) |
| TBIL (μ mol/L) | 18 (8-51) |

BMI: Body mass index; ALT: Alanine aminotransferase; AST: Alanine aminotransferase; ALP: Alkaline phosphatase; GGT: Gamma-glutamyl transpeptidase; TBIL: Total bilirubin.

atropine. In 5 patients, as the lithotomy basket failed to open, the stones were pushed into the intestinal cavity using a combination of ultrafine choledochoscopy and low-dose atropine.

Intraoperative conditions

The average operation time was 19.4 \pm 7.8 minutes. Overall, the operation time was short, and the operation was simple. Intraoperative blood loss was 26.3 \pm 7.4 mL. The postoperative durations of activity, diet, and extubation were 6.7 \pm 2.0, 9.0 \pm 3.4, and 1.9 \pm 0.6 hours, respectively. None of the patients had postoperative jaundice (Table 2).

Postoperative complications

No serious complications, including postoperative hemorrhage, pancreatitis, bile leakage, biliary tract infection, biliary stricture, or residual stone, occurred in any of the 17 patients.

Follow-up outcomes

All patients were followed up regularly after surgery. During the follow-up period, none of the patients had preoperative symptoms such as biliary colic, jaundice or fever. The symptom remission rate was 100%. During the follow-up period, none of the patients experienced stone recurrence. No patients developed other surgery-related complications during the follow-up period.

DISCUSSION

In this study, we first demonstrated that the treatment of Oddi intersphincter stones using ultrafine choledochoscopy combined with low-dose atropine had a high success rate, a short operation time and a low incidence of postoperative complications. In addition, patient symptoms were significantly relieved, and the risk of stone recurrence was low after surgery.

An intersphincter stone is a special type of choledocholithiasis. Under traditional choledochoscopy, intermittent water injection into the common bile duct is typically applied to increase biliary pressure. The diastolic space of the Oddi sphincter was opened, and a mesh basket was used to remove the stone. Traditional choledochoscopy has an effect on upper sphincter intermuscular stones. However, owing to disturbances, the sphincter of Oddi is prone to spasms, which affect the stone removal success rate. In addition, as a traditional choledochoscope is too thick to enter the sphincter, stones located between the middle and lower sphincter are likely overlooked; therefore, the success rate of stone removal is relatively low. In addition, blindly pushing stones with mesh baskets easily causes complications such as aggravation of stone incarceration or intestinal injury. Owing to the advantages of a small diameter, flexible operation and clear vision, the ultrafast choledochoscope can better enter the Oddi intersphincter area and accurately detect and remove stones. The sphincter of Oddi is relaxed by atropine, allowing the ultrafine choledochoscope to be further extended into

Table 2 Intraoperative and postoperative data of patients, mean \pm SD/median (minimum-maximum)

| Variables | Total |
|--|----------------|
| Operation time (minute) | 19.4 \pm 7.8 |
| Intraoperative blood loss (mL) | 26.3 \pm 7.4 |
| Postoperative activity time (hour) | 6.7 \pm 2.0 |
| Postoperative feeding time (hour) | 9.0 \pm 3.4 |
| Postoperative extubation time (hour) | 1.9 \pm 0.6 |
| Postoperative ALT (U/L) | 56 (12-137) |
| Postoperative AST (U/L) | 24 (12-46) |
| Postoperative ALP (U/L) | 88 (38-218) |
| Postoperative GGT (U/L) | 56 (7-432) |
| Postoperative TBIL (μ mol/L) | 19 (7-34) |
| Elevated serum amylase (yes/no) | 0/17 |
| Bile leakage (yes/no) | 0/17 |
| Biliary tract infection (yes/no) | 0/17 |
| Biliary stricture (yes/no) | 0/17 |
| Residual stone (yes/no) | 0/17 |
| Postoperative occult blood in stool (yes/no) | 0/17 |
| Stone recurrence (yes/no) | 0/17 |
| Postoperative symptom relief (yes/no) | 17/0 |

ALT: Alanine aminotransferase; AST: Alanine aminotransferase; ALP: Alkaline phosphatase; GGT: Gamma-glutamyl transpeptidase; TBIL: Total bilirubin.

the intestinal lumen, which further increases the success rate of stone removal.

In this study, Oddi intersphincter stones were successfully removed in all 17 patients by using an ultrafine choledochoscope combined with low-dose atropine, yielding a success rate of 100%. This result is consistent with a recent finding by Nie *et al*[9] that ultrafine choledochoscopy has a high success rate in the treatment of biliary stones. The complication rate of choledochoscopic surgery is approximately 7%-10% [10]. Traditional ERCP combined with sphincterotomy or mechanical lithotomy also has several shortcomings in the treatment of Oddi intersphincter stones, including large surgical trauma, high complication rates and incomplete stone removal [11]. As an anticholinergic drug, atropine relaxes smooth muscles and relieves spasms. During biliary surgery, atropine relaxes the sphincter of Oddi and improves the patency of the biliary tract, facilitating stone removal. Moreover, atropine reduces spasm reactions in the Oddi sphincter during surgery, facilitates the extraction of stones, reduces intraoperative difficulties, improves the success rate of surgery, and reduces the risk of postoperative complications [12,13]. Moreover, the dosage of atropine is controlled within a small range (0.5–1 mg), which effectively prevents adverse effects. For patients with more severe incarcerated stones, the use of intraoperative lithotripsy devices improves the removal success rate. In this study, no serious complications, such as postoperative hemorrhage, pancreatitis or bile leakage, were noted in any of the patients after surgery, suggesting that ultrafine choledochoscopy combined with low-dose atropine is safe for the treatment of Oddi intersphincter stones. As all the stones are completely removed under direct vision, the accuracy and safety of treatment could be significantly improved [14]. Therefore, ultrafine choledochoscopy through the gallbladder duct combined with low-dose atropine has the advantages of less trauma, faster postoperative recovery, and fewer complications. For patients with a history of cholecystectomy, an ultrafine choledochoscope could be inserted through the gallbladder duct, and this technique could also be used as a new treatment for Oddi intersphincter stones.

Although the present study results indicate that ultrafine choledochoscopy combined with low-dose atropine has a satisfactory effect on the treatment of Oddi intersphincter stones, the sample size of the study was relatively small, and a control group was lacking. It is necessary to increase the sample size and establish a control group to further verify the effectiveness and safety of this technology. In addition, the optimal dosage and timing of atropine should be further explored to optimize the treatment regimen.

CONCLUSION

In conclusion, this study suggests that ultrafine choledochoscopy combined with low-dose atropine is effective and safe for the treatment of Oddi intersphincter stones, with a high surgical success rate, a low incidence of postoperative

complications, and a low risk of stone recurrence. This method provides new ideas and choices for the minimally invasive treatment of biliary calculi and has good clinical application prospects.

FOOTNOTES

Author contributions: Hu XS and Wang Y prepared this manuscript; Pan HT and Zhou S performed the statistical analysis and the literature research; Hu XS, Zhu C and Chen SL contributed to data collection and analysis; Jin H and Pang Q played indispensable roles in the study design, data analysis and manuscript preparation as the co-corresponding authors; Jin H conceptualized, designed, and supervised the whole process of the study; Pang Q was responsible for data re-analysis, figures and tables plotting, language polishing, and literature search. This collaboration between Jin H and Pang Q is crucial for the publication of this manuscript.

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