Value of enhanced recovery after surgery in patients undergoing endoscopic retrograde cholangiopancreatography with intravenous anaesthesia for choledocholithiasis: a retrospective observational study

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Abstract

Introduction: *Enhanced recovery after surgery (ERAS) is rarely used in minimally invasive endoscopic surgery, especially in endoscopic retrograde cholangiopancreatography (ERCP).*
Aim: *This study evaluated the safety and efficacy of the ERAS protocol in patients undergoing ERCP for choledocholithiasis.*
Material and methods: *The study had a retrospective design and included patients with biliary tract stones who underwent ERCP between June 2019 and November 2022. Patients who received the ERAS protocol between June 2021 and November 2022 were enrolled as an ERAS group, and those who received traditional perioperative treatment between December 2019 and May 2021 were enrolled as a control group.*
Results: *A total of 349 patients were enrolled (ERAS group, n = 185; control group, n = 164). The cannulation and stone extraction success rates were significantly higher in the ERAS group than in the control group ($p < 0.05$). The incidence of postoperative pancreatitis was significantly lower in the ERAS group ($p = 0.02$), but there were no significant differences in other complications. The postoperative hospital stay was significantly shorter in the ERAS group than in the control group ($p < 0.001$), with no statistically significant differences in costs according to surgical period, or in total costs, between the 2 groups.*
Conclusions: *Application of the ERAS protocol is safe and feasible in patients undergoing ERCP for choledocholithiasis. The ERAS protocol can accelerate recovery, reduce postoperative pain, and shorten the hospital stay without increasing the cost of treatment.*

Key words: *choledocholithiasis, enhanced recovery after surgery, intravenous anaesthesia, endoscopic retrograde cholangiopancreatography.*

Introduction

Enhanced recovery after surgery (ERAS) is a perioperative approach that involves implementing a series of evidence-based, optimized treatment measures involving surgery, anaesthesiology, and nursing in a multidisciplinary setting [1]. ERAS has numerous advantages when compared with traditional perioperative measures [1, 2]. Several studies have demonstrated that ERAS is effective in reducing hospitalization costs and shortening the hospital stay without increasing the incidence of postopera-

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tive complications, readmissions, or mortality [3, 4]. Furthermore, ERAS has been shown to improve the 5-year survival rate of patients undergoing various types of general surgery, including colorectal surgery and gastrectomy [5, 6]. International guidelines for the application of ERAS in general surgery have been published [7, 8].

Choledocholithiasis is a common gastrointestinal disease that becomes more prevalent with age. The incidence of choledocholithiasis is increasing as a result of improvement in the country's economy and changes in dietary habits. Studies have shown that approximately 16% of patients with cholelithiasis are diagnosed to have choledocholithiasis. The incidence of choledocholithiasis increases gradually with age and may affect up to 20% of the population [9]. Endoscopic retrograde cholangiopancreatography (ERCP) was first introduced in 1968 and has become an important diagnostic and treatment method for common bile duct stones because of its advantages of minimal trauma, rapid postoperative recovery, and repeatability [10]. Although ERCP has advantages, complications such as pancreatitis, bleeding, perforation, and cholecystitis may still occur after the procedure as a result of both patient and operator factors [11]. According to domestic reports, the overall incidence of complications after ERCP is approximately 7.92%, with a serious complication rate of 0.37% and a mortality rate of 0.26% [12]. Invasive surgery, such as throat reflex, sphincterotomy, and drainage can cause discomfort and severe complications, including arrhythmia, laryngospasm, bleeding, and aspiration. Common bile duct stones mostly affect elderly patients with underlying conditions, such as cardiopulmonary disease, and the surgical position is often prone or side prone, which interferes with respiratory function and increases the risks of anaesthesia. Application of intravenous anaesthesia for ERCP has increased patients' perioperative requirements in terms of cardiopulmonary function, while at the same time their demands for intraoperative and postoperative pain relief and comfort are increasing. Despite the widespread use of ERAS in various surgical disciplines and the relevant expert consensus having been reached, ERAS is rarely used in minimally invasive endoscopic surgery, especially in ERCP. There is no expert consensus or relevant guidelines on this subject. Therefore, we considered it worthwhile to explore whether the ERAS concept is effective and safe in patients undergoing ERCP under intravenous anaesthesia for choledocholithiasis.

Aim

This study investigated the effectiveness and safety of ERAS in these patients by comparing clinical data between a traditional perioperative group and an ERAS group.

Material and methods

The clinical data for patients who underwent ERCP for choledocholithiasis between June 2019 and November 2022 were retrospectively analysed to establish a prospective ERCP surgery database based on electronic medical records. Patients with choledocholithiasis who received traditional treatment between June 2019 and May 2021 were included as a control group, and those who received ERAS between June 2021 and November 2022 were enrolled as the ERAS group. Written informed consent was obtained from all study participants or one of their family members.

The study inclusion criteria were as follows: age 18–70 years, diagnosis of common bile duct stones or dilatation and icteric choledocholithiasis, and no serious heart or lung disease. The following exclusion criteria were applied: choledocholithiasis > 1.5 cm in diameter; malignant biliary tract tumour; severe cardiopulmonary or renal insufficiency; American Society of Anesthesiologists grade III or above; allergy to contrast medium; history of digestive tract reconstruction surgery; and unsuitable for ERCP because of oesophageal or gastric disease.

Perioperative management

The perioperative management in the ERAS group and the control group are shown in Table I. The ERAS protocol included the following: (1) ERCP preoperative nursing education; (2) screening for nutritional risks; (3) assessment of thrombotic risks and prevention; (4) anaesthesia and respiratory joint consultation; (5) prohibition of solid food intake for 6 h before surgery – allowed to drink 250–500 ml of 10% glucose solution 4–6 h before surgery; (6) intravenous use of fentanyl citrate (0.05 mg) + propofol (2 mg/kg) for induction anaesthesia before surgery; (7) monitoring of patients' vital signs such as blood oxygen saturation, heart rate, blood pressure during

Table I. Perioperative management measures of the ERAS group and Control group

Item	ERAS group	Control group
Preoperative preparation	1. ERCP preoperative nursing education-including the general operation process, perioperative measures, and possible postoperative discomfort, etc. 2. Screening for nutritional risks, formulation of nutritional support plan 3. Assessment of thrombotic risks and prevention 4. Anaesthesia and respiratory joint consultation for patients with poor lung function, nebulization inhalation and respiratory exercises according to patient's lung function 5. Prohibition of solid food intake for 6 h before surgery, allowed to drink 250–500 ml of 10% glucose solution 4–6 h before surgery	1. Routine admission education 2. Fasting and prohibition of drinking for 12 h before surgery
Intraoperative	1. Intravenous use of fentanyl citrate (0.05 mg) + propofol (2 mg/kg) for induction anaesthesia before surgery, maintenance of propofol (250–300 mg/h) during surgery 2. Monitoring of patient's vital signs such as blood oxygen saturation, heart rate, blood pressure during surgery 3. Room temperature was set at 24°C, and a warming blanket was used if necessary to maintain the patient's body temperature between 36°C and 37°C	1. Intramuscular injection of 100 mg pethidine hydrochloride and 10 mg diazepam injection 30 min before surgery 2. 1 mg atropine sulphate injection and lidocaine gel topical anaesthesia of the throat
Postoperative management	1. Indomethacin suppository within 30 min of surgery 2. Somatostatin to inhibit glandular secretion for patients with high risk factors for post-ERCP pancreatitis 3. Encourage early activity after getting out of bed if no discomfort within 2 h of surgery 4. Postoperative hour 6: If serum amylase is normal and the patient has no abdominal discomfort, give a small amount of liquid diet based on intraoperative circumstances 5. Postoperative day 1: Recheck serum amylase, and if the level is normal and the patient has no abdominal pain, vomiting, black stool, etc., start with a clear liquid diet and gradually transition to a normal diet	1. Postoperative ECG monitoring until the next day's rounds to determine whether to stop monitoring 2. Fasting after surgery until the next day

surgery; (8) room temperature was set at 24°C and a warming blanket was used if necessary to maintain the patient's body temperature between 36°C and 37°C, with maintenance of propofol (250–300 mg/h) during surgery; (9) indomethacin suppository within 30 min after surgery, and somatostatin to inhibit glandular secretion for patients with high-risk factors for post-ERCP pancreatitis; (10) encourage early activity after getting out of bed if no discomfort within 2 h after surgery; (11) postoperative hour 6: if serum amylase is normal and the patient has no abdominal discomfort, give a small amount of liquid diet based on intraoperative circumstances; and (12) postoperative day 1: recheck serum amylase, and if the level is normal and the patient has no abdominal pain, vomiting, black stool, etc., start with a clear liquid diet and gradually transition to a normal diet.

During the operation, controlled infusion of 4–6 ml/kg·h was used in both groups. For all patients after operation, according to the patient's age, underlying diseases, etc., appropriate fluids were given after surgery; broad-spectrum antibiotics were given routinely after surgery to prevent infection.

Outcomes

The main observation indicators included successful intubation and stone removal rates, time until first food intake after surgery, pain score when returning to the ward after surgery, occurrence of complications after ERCP, anaesthesia-related complications, and postoperative economic indicators.

Statistical analysis

Descriptive statistics were calculated for demographic and clinical variables and are reported as the mean ± standard error of the mean. Categorical variables were compared between groups using the χ^2

test. Quantitative variables were compared between the groups using Student's *t*-test if normally distributed and the Mann-Whitney test if not. The Bonferroni test was used as a post hoc test for intergroup analysis. The data were analysed using SPSS version 17.0 (SPSS Inc., Chicago, IL, USA). A *p*-value < 0.05 was considered statistically significant.

Results

Baseline characteristics

A total of 349 patients (186 male, 163 female) were enrolled in the study (ERAS group, *n* = 185; control group, *n* = 164). There was no significant difference in age, sex, white blood cell count, or the total bilirubin, direct bilirubin, alanine aminotransferase, aspartate aminotransferase, or albumin level before surgery between the 2 groups ($p > 0.05$) (Table II). There was also no significant between-group difference in American Society of Anesthesiologists score or complications ($p > 0.05$) (Table II).

Comparison of intraoperative outcomes

Intraoperative angiography revealed no significant difference in stone size between the 2 groups (11.15 ±8.90 mm vs. 10.93 ±9.14 mm, $p = 0.84$) or in the frequency of duodenal diverticulum ($p = 0.90$). The rates of successful intubation and stone extraction were significantly higher in the ERAS group than in the control group (91.89% vs. 80.49% and 81.89% vs. 78.08%, respectively, $p < 0.05$). However, there was no statistically significant difference in stone removal technique ($p = 0.23$) or pancreatic duct stent placement ($p = 0.61$) between the 2 groups (Table III).

Comparison of postoperative complications

Pancreatitis occurred in 11 (5.95%) cases in the ERAS group and 22 (13.41%) cases in the control group; the difference was statistically significant ($p = 0.02$). There were 4 cases of postoperative gastrointestinal bleeding (ERAS group, *n* = 2; control group, *n* = 2), 1 case of gastrointestinal perforation (in the control group), and 7 cases of acute cholangitis (ERAS group, *n* = 4; control group, *n* = 3). There was no statistically significant difference in the complication rate between the 2 groups (Table IV). There was 1 case of aspiration pneumonia in each study group and 16 cases of hypoxaemia (ERAS group, *n* = 9; control group, *n* = 7); the between-group differences were not statistically significant (Table IV).

Table II. Demographic characteristics of included patients

Characteristics	ERAS group (*N* = 185)	Control group (*N* = 164)	*P*-value
Age [year]	72.00 (8.26)	72.89 (8.24)	0.97
Gender (male/female)	104/81	91/73	1.00
WBC [× 10^9/l]	7.27 (3.84)	7.72 (4.51)	0.10
TB [mmol/l]	34.74 (71.67)	49.24 (53.18)	0.16
DB [mmol/l]	35.79 (58.11)	34.74 (43.22)	0.14
ALT [U/l]	117.62 (188.86)	126.42 (147.63)	0.71
AST [U/l]	97.21 (208.26)	113.24 (184.31)	0.61
Albumin [g/l]	37.40 (4.84)	35.08 (5.57)	0.10
ASA (II/III/IV)	89/60/12	87/61/16	0.75
Comorbidity:			
Hypertension	30 (16.21)	32 (19.51)	0.42
Diabetes	21 (11.35)	18 (10.98)	0.87
Coronary heart disease	24 (12.97)	21 (12.80)	0.96
COPD	8 (4.32)	9 (5.49)	0.61
Malignant tumour	9 (4.86)	10 (6.10)	0.61
Others	10 (5.40)	9 (5.49)	0.97

Data expressed as mean (SD) or n (%); ERAS – enhanced recovery after surgery, WBC – white blood cell count, TB – total bilirubin, DB – direct bilirubin, ALT – alanine aminotransferase, AST – aspartate aminotransferase, ASA – American Society of Anesthesiologists, COPD – chronic obstructive pulmonary disease.

Table III. Comparison of traditional ERAS group Control group

Characteristics	ERAS group (*N* = 185)	Control group (*N* = 164)	*P*-value
Stone size [mm]	10.93 (9.14)	11.15 (8.90)	0.84
Duodenal papillary diverticulum (%)	62 (33.51)	56 (34.15)	0.90
Success rate of canulation (%)	170 (91.89)	132 (80.49)	0.00
Stone removal rate (%)	165 (81.89)	128 (78.05)	0.00
Stone removal technique (%):			0.23
EST	48 (25.95)	32 (19.51)	
EPBD	51 (27.57)	32 (19.51)	
EST + EPBD	66 (35.68)	64 (39.02)	
Pancreatic stent placement (%)	7 (3.78)	8 (4.88)	0.61

Data expressed as mean (SD) or n (%); ERAS – enhanced recovery after surgery, EST – endoscopic sphincterotomy, EPBD – endoscopic papillary balloon dilatation.

Table IV. Comparison of postoperative complications between the 2 groups

Characteristics	ERAS group (*N* = 185)	Control group (*N* = 164)	*P*-value
Pancreatitis	11 (5.95%)	22 (13.41%)	0.02
Bleeding	2 (1.08%)	2 (1.22%)	0.90
Perforation	0 (0%)	1 (0.61%)	0.29
Acute cholangitis	4 (2.16%)	3 (1.83%)	0.82
Aspiration pneumonia	1 (0.54%)	1 (0.61%)	0.93
Hypoxaemia	9 (4.87%)	7 (4.27%)	0.79
In-hospital mortality	0 (0%)	0 (0%)	–

Data expressed as n (%), ERAS – enhanced recovery after surgery.

Table V. Comparison of economic indicators between the 2 groups of ERCP

Characteristics	ERAS group (*N* = 185)	Control group (*N* = 164)	*P*-value
Time to first oral after surgery [days]	0.78 (1.25)	1.78 (1.10)	< 0.001
NRS score	1.92 (0.52)	2.58 (0.87)	< 0.001
Length of hospital stay postoperative [days]	3.84 (1.43)	5.72 (1.24)	< 0.001
Intraoperative cost (RMB)	6126.15 (2721.06)	6007.13 (2637.97)	0.56
Total cost (RMB)	22949.48 (8550.19)	25326.87 (8707.82)	0.74

Data were expressed as mean (SD) or n (%), ERAS – enhanced recovery after surgery.

The time until first oral intake was significantly shorter in the ERAS group than in the control group (0.78 ±1.25 vs. 1.78 ±1.25, $p < 0.001$), and the Numeric Rating Scale score was significantly lower in the ERAS group than in the control group (1.92 ±0.52 vs. 2.58 ±0.87, $p < 0.001$). The average postoperative hospital stay was significantly shorter in the ERAS group than in the control group (3.84 days vs. 5.72 days; $p < 0.001$). There was no significant difference in total perioperative costs between the 2 groups (Table V).

Discussion

With the development of minimally invasive technology, ERCP now has an important position in clinical practice. ERCP has the advantages of being minimally invasive and effective with a short hospital stay and a low incidence of complications. However, like general endoscopic operations, the traditional method used for anaesthesia in ERCP is usually local anaesthesia in the throat, which may cause nausea and vomiting during endoscopic and

surgical procedures, and if severe, the patient cannot cooperate during the operation. Painless requirements increase during the process. Rational application of the ERAS concept can optimize perioperative management of patients, reduce traumatic stress and complications, shorten the length of hospital stay, and accelerate recovery while maintaining safety and efficacy. There are few reports on ERAS in patients who have undergone ERCP for choledocholithiasis. In this study, the concept of ERAS was applied in elderly patients with choledocholithiasis who underwent ERCP at our institution.

ERAS was first proposed in 1997 by Professor Kehlet at the University of Copenhagen. ERAS can reduce the physiological and psychological stress caused by surgery and drug treatment, reduce the negative impact on patients, and accelerate postoperative recovery [1]. The concept of ERAS is now widely used in the settings of colorectal surgery, orthopaedics, gynaecology, gastric cancer, and thoracic surgery, and relevant studies have shown it to have a significant clinical effect. During the perioperative period, patients undergoing ERCP are subjected to multiple psychological and physiological stresses. Anxiety was alleviated in our ERAS group by specialist nurses who provided patients and their families with specific preoperative explanations about ERCP. Use of intraoperative intravenous anaesthesia also reflects the concept of ERAS. Studies have shown that traditional local anaesthesia for the throat cannot relieve postoperative pain, especially in elderly patients, and often causes restlessness and frequent bouts of hiccups during the operation, potentially increasing the risk of patients being unable to cooperate with further procedures. Intraoperative anaesthesia can effectively reduce intraoperative pain, and studies have shown that ERCP under intravenous anaesthesia does not increase the incidence of intraoperative and postoperative complications. Effective intravenous anaesthesia can stabilize the patient's mental state and reduce discomfort. In our present study, the success rates of intubation and stone extraction were higher in the group that received ERAS than in the group that received traditional management. Our findings may reflect reduction of agitation in patients under intravenous anaesthesia and the fact that the operator can perform surgery more efficiently, especially when the duodenal papilla is dilated or for stone removal, patients in the traditional treatment group often have obvious abnormalities and increased agitation, and sometimes the operating doctor cannot perform the operation. If the operation is not stopped, the intubation or stone extraction will fail.

Pancreatitis is one of the common complications after ERCP and often results in postoperative pain, a longer hospital stay, and increased hospitalization costs. Many studies have shown that indomethacin can effectively reduce the incidence of postoperative pancreatitis. Patients in our study received indomethacin routinely after surgery. The incidence of postoperative pancreatitis was lower in our ERAS group than in our control group, which is also consistent with previous studies [13–15]. In our study, the preoperative duration of fasting and withholding of fluids was shorter in the ERAS group that in the control group, as was the postoperative hospital stay. There was no significant difference between our 2 study groups in terms of operating costs or total costs. Although the cost of anaesthesia was higher in our patients who received ERAS, there was no increase in the total cost, which may reflect the shorter postoperative hospital stay and the lower incidence of complications.

This study has several limitations. First, it was based on a retrospective analysis of data obtained from medical records, so its results must be interpreted with caution. Moreover, allocation to ERAS or traditional treatment was not randomized, and different approaches to perioperative care may have affected postoperative recovery. Second, the follow-up duration was limited, so we were unable to evaluate the impact of different perioperative care methods on long-term survival outcomes. However, despite these limitations, this study provides meaningful data on the safety and enhanced recovery after surgical treatment of choledocholithiasis by ERCP.

Conclusions

ERCP is safe and effective for patients with choledocholithiasis under the ERAS protocol. It can effectively shorten the postoperative recovery time and does not increase treatment costs.

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Conflict of interest

The authors declare no conflict of interest.

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