A Clinical Observational Study on the Application of Enhanced Recovery After Laparoscopic Pancreaticoduodenectomy

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Abstract

Background: The safety and feasibility of enhanced recovery after surgery (ERAS) for laparoscopic pancreaticoduodenectomy (LPD) are unclear. The aim of this retrospective clinical study was to evaluate the impact of ERAS protocols for LPD.

Methods: Between March 2016 and December 2018, a total of 34 consecutive patients with ERAS for LPD were prospectively enrolled and compared with 68 consecutive patients previously treated for non-ERAS after LPD during an equal time frame. The intraoperative and postoperative data were collected and comparatively analyzed.

Results: The mean length of postoperative hospital stay (15.8±3.4 and 23.1±5.1 days, $P<0.001$) and total medical costs (¥14.3±4.8 x10^4 and ¥15.8±4.9 x10^4, $P=0.017$) were reduced significantly in ER group than those in non-ER group. The operation time (462.7±117.0 vs 450.9±109.8 min, $P=0.627$) and intraoperative blood loss (523.5±270.0 vs 537.5±241.8 mL, $P=0.800$) were similar in the two groups. The complications of patients with ERAS protocols were not increased ($P>0.05$). No difference in mortality and readmission rates was found.

Conclusions: The ERAS is safe and effective in the perioperative period of LPD. It could effectively reduce the length of postoperative stay and medical costs, and does not increase the incidence of postoperative complications.

Introduction

Enhanced recovery after surgery (ERAS) protocols are referred to as “fast-track surgery”, which are multimodal, evidence-based approaches to the perioperative management of patients undergoing different types of operations that are designed to reduce the surgical stress response and accelerate recovery [1]. The main principle of ERAS protocols is to reduce intraoperative stress and prevent immunosuppression. Moreover, ERAS protocols aim to decrease the incidence of postoperative complications and the length of hospital stays, which in turn reduce hospitalization costs. Additionally, preventing both tumour seeding and recurrence are included in the components of ERAS protocols [2,3]. In recent years, similar promising studies have been gradually reported for various types of surgery with important clinical benefits, especially in colorectal surgery [4–7].

With the increased publication of ERAS guidelines to optimize patient outcomes after more complex and high-risk surgical procedures, there is growing enthusiasm and interest among healthcare professionals for studies on ERAS programmes in patients after open pancreatoduodenectomy (OPD) [8–11]. Encouragingly, most initial studies have shown the feasibility and safety of ERAS for OPD, such as early discharge [11], decreased morbidity [12], and fewer postoperative complications[13]. However, laparoscopic PD (LPD) remains a challenging procedure due to its technical limitations and the need for advanced skills in laparoscopy. Several comparative studies show that LPD had earlier discharge [14], lower blood loss[15], and longer disease-free survival[16] compared to OPD. Of note, LPD is not recommended as a preferred surgical approach if the surgeon has not mastered the long learning curve according to some clinical observations because of higher morbidity, more severe pancreatic fistulae and post-pancreatectomy haemorrhage [17,18]. Despite the disagreement about the application of LPD, the number of LPD surgeries performed is increasingly rapidly worldwide each year. To date, few studies have been performed regarding ERAS programmes for LPD. Therefore, the effectiveness and safety of ERAS for LPD remain unclear. Further study is urgently required to explore the effects of ERAS programmes on perioperative outcomes in patients undergoing LPD.

In the present retrospective observational study, we primarily aimed to investigate the effect of ERAS protocols in patients after LPD. The secondary aims were to assess the postoperative recovery and outcomes of LPD in patients in an academic medical centre in China.

Materials And Methods

Study population

This is a retrospective clinical study on a collected data base. In our institution, we have applied ERAS protocols for some patients undergoing LPD since March 2018. Between March 2016 and December 2018, a total of 102 patients who underwent LPD were enrolled in this study, including pancreatic cancer and lower bile duct carcinoma. These surgeries were performed by Dr. De-Wei Li and Dr. Xiong Yan, who are experienced laparoscopic surgical experts [19,20] and have completed more than 50 cases of LPD. Among these cases, 34 patients were prospectively included in enhanced recovery (ERAS group). These patients were compared with 68 consecutive patients after LPD under the care of the same consultants previously receiving standard care during an equal time frame (non-ERCP group, non-ER). Patients who had tumour metastasis and other organ resection were not considered eligible for this study. This study protocol conformed to the ethical guidelines of the 1975 Helsinki Declaration and has been reviewed and approved by the Ethics Review Board of the First Affiliated Hospital of Chongqing Medical University. All patients and/or their legal guardians were required to provide informed consent to participate in this study. Clinical characteristics between two groups were compared using the following risk factors: gender, age, body mass index (BMI), American Association of Anaesthesiologists (ASA) score, and Child-Pugh score as well as measurements of white blood cells (WBC), neutrophils, haemoglobin, albumin, total bilirubin (TB), direct bilirubin (DB), alanine aminotransferase (ALT), and aspartate aminotransferase (AST) (Table 1). Patients were followed up as outpatients or by telephone. Patients’ complications after discharge and whether they were readmitted to the hospital within 30 days of the operation because of the complications were inquired about during follow-up. The deadline for follow-up was the end of March 2019.

Table 1
Patients characteristics

Characteristics	ER group (n = 34)	Non-ER group (n = 68)	P value
Gender (male)	19 (55/9%)	39 (57.4%)	1.000
Age (years)	59.3 ± 9.5	61.1 ± 9.1	0.374
BMI (Kg/m^2)	22.3 ± 1.8	22.9 ± 1.9	0.174
Abdominal surgery history (Y)	10 (29.4%)	17 (25.0%)	0.641
Preoperative abdominal pain	14 (41.2%)	31 (45.6%)	0.672
Preoperative diabetes (Y)	7 (20.6%)	12 (17.6%)	0.719
Preoperative hypertension (Y)	12 (35.3%)	22 (32.4%)	0.766
Hemoglobin (g/L)	122.1 ± 14.53	117.6 ± 15.4	0.149
WBC (10^9/L)	7.6 ± 2.3	7.7 ± 2.4	0.713
Neutrophil (10^9/L)	4.4 ± 2.0	5.9 ± 6.2	0.091
Albumin (g/L)	39.7 ± 4.4	40.8 ± 4.0	0.216
TBIL (μmol/L)	135.4 ± 81.7	122.7 ± 83.1	0.465
DBIL (μmol/L)	101.1 ± 77.9	97.9 ± 73.3	0.842
ALT (U/L)	158.0 ± 130.8	136.1 ± 102.8	0.397
AST (U/L)	140.7 ± 119.6	120.0 ± 99.0	0.388
PT (s)	12.9 ± 1.5	13.0 ± 1.6	0.652
ASA score			0.337
I	16	36	
II	18	29	
III	0	3	
Child-Pugh Grade			1.000
A	14	27	
B	20	41	

Abbreviations: ER: enhanced recovery after surgery; BMI: Body mass index; WBC: white blood cells; TBIL: total bilirubin; DBIL: direct bilirubin; ALT: alanine aminotransferase; AST: aspartate *aminotransferase*; PT: prothrombin time; ASA: American Society of Anesthesiologists score.

ERAS protocols

ERAS protocols were designed based on previously published ERAS guidelines [1], and we further refined and established our own standardized programmes (Table 2). Early oral intake and ambulation, active pain control, avoidance of unnecessary indwelling medical tubes, and promotion of patient autonomy were encouraged if the condition of the patients allowed. Postoperative oral intake of liquids was started on postoperative day (POD) 1–2, and elemental diet was started on POD 2, and solids were started on POD 3–4. Intake of rice porridge was started on POD 3 in parallel with elemental diet. Postoperative fluid management was adjusted based on oral intake. The intravenous fluid infusion volume was controlled within 1000-1500ml. Nasogastric tubes were removed on POD 1 if nasogastric output was < 300 ml/day. The urinary catheter was also removed on POD 1. Intra-abdominal drains were removed on POD 3 if amylase was less than 3-fold higher than the serum level and output was < 50 ml/d. Physiotherapy was started on POD 1 and continued until discharge. For postoperative prophylaxis, piperacillin/tazobactam sodium was administered intravenously on the operative day (4.5 g, three times).

Table 2
Protocols of the ERAS program and traditional care for patients receiving LPD

	ER group	Non-ER group
Preoperative	Counseling about fast-track rehabilitation programme while admission. Intake of clear fluids up to 3 hours before anesthesia and normal oral nutrition until 6 hours before surgery. No bowel preparation before surgery	Traditional informed consent. Overnight fasting. Oral bowel preparation.
Intraoperative	Restrictive intravenous fluids Perioperative antibiotic Somatostatin Acid suppression Analgesia infusion pump Postoperative vomiting prophylaxis with 5-HT receptor antagonist	Restrictive intravenous fluids Perioperative antibiotic Somatostatin Acid suppression Analgesia infusion pump
POD 1	Clear oral liquids and restricted amounts of intravenous fluids Steam inhalation Anti-thrombotic prophylaxis Removal of urinary catheter Removal of nasogastric tube if < 300 ml Mobilization out of bed for >1 h or at least 3 times Physiotherapy	Fasting till flatus and no restricted amounts of intravenous fluids Steam inhalation Anti-thrombotic prophylaxis On-bed movement
POD 2	Oral elemental diet Enhanced mobilization out of bed for >2 hours or at least 6 times	Removal of urinary catheter after intermittent clipping Removal of nasogastric tube after flatus

Abbreviations: ERAS: enhanced recovery after surgery; LPD: laparoscopic pancreaticoduodenectomy; 5-HT: 5-hydroxytryptamine; POD post-operation day.

	ER group	Non-ER group
POD 3	Oral semisolid diet Stop antibiotics Removal of intra-abdominal drains if drain amylase less than 3-fold serum and 50 mL/d production Enhanced mobilization out of bed for >4 hours	Oral intake of elemental diet depending on patient's progress including flatus Removal of urinary catheter after intermittent clipping Bedside sitting and standing according to patient's ability
POD 4	Gradual transfer to regular diet All medication stopped except oral proton pump inhibitors and multivitamin	Oral liquids Stop antibiotics according to the inflammatory index Removal of intra-abdominal drains if drain amylase less than 3-fold serum and 50 mL/d production Untargeted mobilization
Discharge criteria	Normal body temperature Ability to take solid foods without vomiting even only 1–2 times/day Adequate mobilization No abdominal pain or controlled abdominal pain by oral pain medications (Tramadol 50mg, no more than twice per day, ¥2.2/tablet) No obvious abnormalities in laboratory test	Normal body temperature Regular diet like the time before illness Adequate mobilization No abdominal pain No obvious abnormalities in laboratory test

Abbreviations: ERAS: enhanced recovery after surgery; LPD: laparoscopic pancreaticoduodenectomy; 5-HT: 5-hydroxytryptamine; POD post-operation day.

Surgical procedures

The standard surgical procedures were performed in all patients, including gastrointestinal anastomosis and the pancreaticojejunostomy (anastomosis of pancreatic duct mucosa and jejunum mucosa). The intra-abdominal drains were routinely placed at the site of the bilioenteric anastomosis and pancreaticojejunostomy.

Outcome measures

To comparatively analyse the effectiveness of ERAS for LPD, a series of clinical parameters were assessed as follows: postoperative stay and total medical costs; duration of surgery and intraoperative blood loss; the first bowel gas time, first diet time, and off-bed activity; and the incidence of postoperative complications, such as pancreatic fistula, biliary fistula, gastric emptying, haemorrhage, abdominal infection, pulmonary infection, and readmission within 30 days of the operation. Patients who underwent LPD and met the following criteria were eligible for discharge (Table 2): normal body temperature, ability to take solid foods, adequate mobilization, no abdominal pain or abdominal pain controlled with oral pain medications and no obvious abnormalities in laboratory tests.

Statistical analysis

SPSS 24.0 statistical software was used to analyse the data. The continuous variable data are shown as the mean ± standard deviation. Differences between groups were assessed using Student's *t* test. Count data were analysed using x^2 test, Fisher's exact test and the rank sum test. A p value < 0.05 was considered statistically significant.

Results

Patient characteristics

This study included 58 men (56.9%) and 44 women (43.1%) with an average age of 60.5 ± 9.2 years. The two groups were similar in terms of demographics and surgical characteristics (all $P > 0.05$) (Table 1). There was no difference in mean age, BMI, ASA score and Child-Pugh score between the ER and non-ER groups. Common laboratory tests, including WBC, TB, DB, AST, ALT and albumin, did not differ significantly between the two groups.

Operative outcomes

The mean length of postoperative hospital stay was 15.8 ± 3.4 and 23.1 ± 5.1 days in the ER group and non-ER group, respectively. No statistically significant differences were observed between the ER and non-ER groups in duration of surgery, intraoperative blood loss and transfusion, which are presented in Table 3. In the ER group, the mean duration of surgery was 462.7 (300–720) minutes, the operative blood loss was 523.5 (250–1200) ml, and 8.8% of patients received an intraoperative transfusion. However, in the non-ER group, the mean duration of surgery, operative blood loss and proportion of patients who received an intraoperative transfusion were 450.9 (300–760) min, 537.5 (250–1500) ml and 11.8%, respectively.

Table 3
Demographics and perioperative variables in patients

Variables	ER group (n = 34)	Non-ER group (n = 68)	P value
Duration of surgery (min)	462.7 ± 117.0	450.9 ± 109.8	0.627
Intraoperative blood loss (ml)	523.5 ± 270.0	537.5 ± 241.8	0.800
Patients transfused (Y)	3 (8.8%)	8 (11.8%)	0.746
Intraoperative biliary drains (Y)	29 (85.3%)	48 (70.6%)	0.143
Pathologic diagnosis			
Pancreatic cancer	18 (52.9%)	43(63.2%)	0.393
Cholangiocarcinoma	8 (23.5%)	12 (17.6%)	0.598
Duodenal adenocarcinoma	5 (14.7%)	7 (10.3%)	0.528
Benign lesion	3 (8.8%)	6 (8.8%)	1.000
Nasogastric tube removal time (Days)	1.8 ± 0.9	3.6 ± 1.1	**< 0.001**
Urinary catheter removal time (Days)	2.1 ± 1.0	3.8 ± 1.1	**< 0.001**
Intra-abdominal drains removal time (Days)	4.2 ± 1.2	7.2 ± 2.6	**< 0.001**
First bowel gas time (Days)	2.7 ± 0.9	4.0 ± 0.9	**< 0.001**
First diet time (Days)	2.0 ± 0.6	3.5 ± 0.7	**< 0.001**
Off-bed activity time (Days)	2.3 ± 0.7	4.2 ± 0.9	**< 0.001**
Postoperative stay (Days)	15.8 ± 3.4	23.1 ± 5.1	**< 0.001**
Total medical cost (¥10^3)	14.3 ± 2.8	15.8 ± 2.9	**0.017**

Abbreviations: ER: enhanced recovery after surgery.

The intravenous fluid infusion rate was 4.0 mL/kg/h. Usually, the ratio of crystalloid to colloid was from 2:1 to 3:1. The ER group had significantly lower total fluid and crystalloid volume than non-ER group ($P < 0.01$). There was no significant different in the colloid volume between two groups. All patients used analgesic infusion pump in both groups.

Postoperative complications

The complications included pancreatic or biliary fistula, haemorrhage, abdominal or pulmonary infection, unplanned reoperation, mortality rate and readmission within 30 days of the operation. There was no statistically significant difference for complications in the two groups ($p > 0.05$) (Table 4). The overall complication rate was 32.4% (11 of 34 patients) in the ER group compared with 35.3% (24 of 68) in the non-ER group ($P = 0.281$). For example, Three patients in the ER group developed a grade B pancreatic fistula after surgery. These patients were healed after treatment with abdominal puncture and B-ultrasound guided-drainage. Two patients with postoperative haemorrhage were underwent a second surgery. The other postoperative complications were treated conservatively. There was no difference in postoperative complications between the patients after LPD performed by Dr. Li and Dr. Yan. The median duration of postoperative fluid management was 9.5 days (range: 7.5–14 days) in the ER group and 14 days (range: 12.5–22 days) in the non-ER group ($P < 0.01$).

Table 4
Surgical complications

Types	ER group (n = 34)	Non-ER group (n = 68)	P value
Pancreatic fistula, n (%)			0.903
Grade A	7	14	
Grade B	3	5	
Biliary fistula, n (%)	1	1	0.615
Postopreative hemorrhage, n (%)	2	1	0.216
Abdominal infection, n (%)	0	1	0.480
Pulmonary infection, n (%)	0	3	0.216
Wound infection, n (%)	0	1	0.480
Delayed gastric emptying, n (%)	1	1	0.615
Pleural effusions or ascites, n (%)	1	1	0.615
Thrombosis, n (%)	0	1	0.480
Unplanned reoperation	0	1	0.480
Mortality	0	1	0.480
Readmission in 30 days, n (%)	1	0	0.157

Cost analysis

The mean total medical costs per patient were ¥14.3 ± 4.8 x10^4 and ¥15.8 ± 4.9 x10^4 in the ER and non-ER groups, respectively ($P = 0.017$, Table 5). Postoperative costs per patient were ¥13.5 x10^4 in the ER group and ¥15.1 x10^4in the non-ER group ($P = 0.019$). ERAS was significantly associated with lower costs for medication, housing, nursing care and disposable material costs ($P < 0.05$) in the ER group compared with the non-ER group. The surgical and anesthetic costs were similar in the two groups ($P > 0.05$). In the enhanced recovery group, these patients had some extra radiological examinations or laboratory examinations to prevent accidental complications due to the enhanced recovery. Other laboratory and radiologic examination costs had no significant difference ($P > 0.05$).

Table 5
Comparison of the main individual cost between two groups

Factors (¥)	**ER group (n = 34)**	**Non-ER group (n = 68)**	**P value**
Total medical costs	$14.3 \pm 4.8 \times 10^4$	$15.8 \pm 4.9 \times 10^4$	**0.017**
Postoperative costs	$13.5 \pm 4.1 \times 10^4$	$15.1 \pm 4.4 \times 10^4$	**0.001**
Housing costs	1341.8 ± 232.5	1962.5 ± 346.5	**< 0.001**
Nursing care costs	634.5 ± 78.6	921.4 ± 67.3	**< 0.001**
Medication	46237.9 ± 1128.4	54102.3 ± 2098.3	**< 0.001**
Disposable material costs	38029.5 ± 2834.8	43004.6 ± 2254.7	**< 0.001**
Laboratory examinations	7475.8 ± 128.3	7587 ± 163.2	0.133
Radiologic examinations	3637.9 ± 56.3	3465.1 ± 86.2	0.441
Extra laboratory and radiologic examinations for ERAS	1327.6 ± 92.1	0	**< 0.001**
Surgical costs	6235.5 ± 273.5	6288 ± 255.9	0.652
Anesthetic cost	3684.3 ± 129.3	3779.4 ± 113.8	0.778
*Other	12673.5 ± 1128.3	11987 ± 1269.6	0.265

Abbreviations: ER: enhanced recovery after surgery. ¥: China Dollars. *Including Pathology, Physiotherapy and Blood.

Compliance with ERAS core elements

The recovery indicators for patients with ERAS or non-ER were comparatively analysed. The retention time of nasogastric tubes, urinary catheters and intra-abdominal drains in the ER group were significantly shorter than that in the non-ER group ($p < 0.001$). In addition, oral elemental diet and targeted mobilization after surgery in the ER group also occurred much earlier than that those in the non-ER group ($p < 0.001$) (Table 6). In addition, there were several patients deviating from the ERAS protocols. The nasogastric tube was removed on POD 1 in 26 (76.5%) patients, but four patients (11.8%) could not start oral intake of an elemental diet on POD 2.

Table 6
Compliance with factors of ERAS protocols

Factors	ER group (n = 34)	Non-ER group (n = 68)	P value
Preoperative counseling	34	0	**< 0.001**
No bowel preparation	30	2	**< 0.001**
Antimicrobial prophylaxis	34	68	-
Restrictive intravenous fluids	34	68	-
Somatostatin	34	68	-
Acid suppression	34	68	-
Analgesia pump	33	65	1.000
Vomiting prophylaxis	29	10	**< 0.001**
Early removal of urinary catheter	21	12	**< 0.001**
Early removal of nasogastric tube	26	13	**< 0.001**
Early removal of intra-abdominal drains	17	9	**< 0.001**
Early oral elemental diet	30	8	**< 0.001**
Anti-thrombotic prophylaxis	34	64	0.298
Steam inhalation	32	59	0.328
Targeted mobilization	33	45	**< 0.001**

Abbreviations: ERAS: enhanced recovery after surgery.

Discussion

To the best of our knowledge, this is the first clinical observational study in China to investigate the feasibility and safety of ERAS protocols in patients after LPD. The present study suggests that ERAS programmes have obvious benefits in facilitating earlier patient recovery, which included earlier first bowel gas time, first diet time, and off-bed activity time; shorter drainage tube retention time; shorter postoperative stay; and lower medical costs. Meanwhile, there was no significant difference in most postoperative complication rates and 30-day readmissions between the two treatments.

Compared to OPD, LPD is a highly invasive surgical procedure with higher risk that requires advanced laparoscopic skills for senior surgeons. The incidence of postoperative complications of LPD is still as high as 30–50%, even when performed by an expert surgeon [21]. Thus, it seems that ERAS programmes for LPD might not be widely accepted. In fact, implementation of ERAS is now expanding across a wide range of complex laparoscopic surgical procedures and specialties, such as colorectal resection [22], liver resection [23], and gynaecologic oncology [24], and the benefits of ERAS have been well proven in these surgeries. For the first time, our observational results demonstrated the safety and efficiency of implementing ERAS protocols for LPD. However, RCTs are required to provide further evidence about ERAS protocols for LPD.

In this study, the postoperative stay was decreased significantly in ER group. This may be clinically important because early oral elemental diet and targeted mobilization lead to fast recovery and increased immunity of patients after surgery, and subsequently reducing the length of hospital stay. In the ER group, earlier first diet and off-bed activity after surgery were encouraged for patients following LPD, which may have resulted in earlier bowel gas. Traditionally, the surgeons used to fear that early feeding could increase the complication rate by stimulating pancreatic secretion, which led to maintaining patients on long fasting periods after OPD [25]. Currently, increasing studies have shown that long-term fasting may lead to slower recovery of intestinal peristalsis[26] and increased risk of metabolic disorders[27,28], which is not conducive to patient recovery. Early enteral feeding can reduce postoperative infections and shorten postoperative hospital stays [29]. Feeding proximally to the anastomosis does not increase the risk of bowel anastomosis [30]. Balzano et al. showed that early feeding did not increase the incidence of pancreatic fistula after surgery but could reduce the incidence of gastric emptying[25]. Considering the complexity of LPD, in our protocols, the patients turned over or moved their limbs on the bed on POD 1, then moved legs on the bedside, and finally got out of bed for small-scale exercise. We thought that the premise for early ambulation was effective analgesia and early removal of various drainage tubes.

The shorter retention time of urinary catheters, nasogastric tubes and intra-abdominal drains could reduce some related postoperative complications. Indwelling urinary catheters can increase the risk of postoperative lung and urinary tract infections [31], and indwelling nasogastric tubes contribute to a high risk of lung infection in patients[32], which further delays patient recovery. Moreover, a multicentre RCT showed that the absence of an intra-abdominal drain after OPD significantly increased the incidence of complications and mortality by 4 fold [33]. Therefore, this practice is reasonable to implement in patients with intra-abdominal drains following LPD. However, this study also suggests that early drain removal based on the amount of postoperative drainage is acceptable in patients undergoing LPD. Indeed, drain removal did not increase the risk of postoperative complications compared to the non-ER group.

Our data suggest the efficiency of ERAS programmes for decreasing postoperative complications and morbidity, which is consistent with a previous RCT on ERAS protocols for OPD [12]. Moreover, a recent retrospective study found that lower pre-albumin level, higher ASA score and longer operative time were independent risk factors for failure of early recovery from OPD and increased complications of ERAS for

OPD [10]. Of note, we found that more patients had pulmonary infections in the non-ER group compared with the ER group. This result may be associated with the early ambulation of ERAS protocols, which could promote expectoration and immunity of patients and decrease the opportunity for pulmonary infection.

ERAS pathways showed reduced medical costs with LPD. Compared to non-ER, surgical and anaesthetic costs were not different, but the costs of wards and beds, laboratory and radiologic examinations, and medications were decreased significantly, which resulted in lower total medical cost. Other reasons for reduced medical costs may be attributed to the shorter postoperative hospitalization time and less postoperative complications, with no increase in the readmission rate. Consequently, the patients could benefit from the reduced healthcare costs of LPD via ERAS programs.

Another important finding was that ERAS programmes did not increase the risk of postoperative haemorrhage and biliary or pancreatic fistula. Given the technically challenging nature of the LPD procedure, it requires higher laparoscopic skill with regard to accurate needle handling to prevent suture tangling in the biliary/pancreatic ducts and intestinal/pancreatic tissues. In our study, the two surgeons were experienced laparoscopic surgical experts and completed the initial learning curve, which could help to avoid technical bias. Moreover, we do not support the recommendation for routine preoperative endoscopic nasal biliary drainage for patients undergoing LPD. Given the minimally invasive nature of LPD, our results should encourage an expansion in the use of ERAS for LPD.

The main limitations of our study are the nature of the retrospective study and the small sample in a single medical centre. We have not compared the surgical effects between LPD and OPD during the same period. To date, there is no widely accepted guideline or recommendation for ERAS programmes for LPD. Therefore, all the basic components of the “fast-track” or ERAS programmes for LPD in our study are based on other protocols for OPD in other different laparoscopic surgical specialties. Moreover, there were a lot of important factors influencing the outcomes after LPD, including surgeons’ laparoscopic surgical, postoperative management of patients, postoperative care from nurses. Our results need to be validated by additional future studies or stratified analysis. Furthermore, compared with the west countries, the mean length of postoperative hospital stay was still longer in both groups. We believe it could be further shortened if Chinese patients are more able to follow the surgeons' guidance. In addition, the introduction of laparoscopic procedure perhaps led to clinicians challenging their traditional viewpoints of postoperative care which has been aided by the ERAS groups research. Therefore, a more evidence based postoperative care program should be introduced in the future.

Conclusion

ERAS protocols for LPD can effectively reduce the length of postoperative stay and medical costs and do not increase the incidence of postoperative complications. However, individualized ERAS measures for LPD should be formulated in light of clinical practice and previous studies. In future studies, more intensive multimodal approaches should be optimized and improved to maximize patient benefit.

Declarations

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Disclosure Statement

No potential conflicts of interest.

Authors' contributions

RL, PC and JCL conceived and designed this study. JC contributed to the acquisition of the data. RL and XY participated in study design and coordination and data analysis and interpretation, and drafted the manuscript. All authors have read and approved the final manuscript.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

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