



## Review

# A review of the current ERAS guidelines for liver resection, liver transplantation and pancreatoduodenectomy

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## ABSTRACT

In perioperative care after liver resection, transplantation and pancreatoduodenectomy, ERAS (Enhanced Recovery After Surgery) recommendations are based on the reducing invasiveness of procedures and the severity of the surgical stress, which results in decreasing complications and enhanced recovery. Recommendations for all three operations can be classified into five groups: recommended for all patients, recommended for special patient groups, rejected for all patients, controversial recommendations, specific recommendations for all three operations.

Preoperative counselling and psychological support, nutritional support, smoking and alcohol cessation, pre- and intraoperative antibiotic prophylaxis, thrombosis prevention, limiting of preoperative hunger and thirst to 4 and 6 h, preoperative intaking carbohydrate rich drink, alcohol-based antiseptics for skin preparation, a goal-directed infusion therapy, providing normothermia, early removal of the drainage tube, glycemic control, dual antiemetic therapy, multimodal analgesia strategies, early oral feeding and activation, audit recommend for all patients. Postoperative antibiotic prophylaxis, enteral and parenteral nutrition, short-acting anxiolytics are recommended for individual patients. It is recommended to avoid Mercedes type incision, use of long-acting anxiolytics and postoperative nasogastric tube. The benefits of preoperative physical exercise, immunonutrition and probiotics are controversial. There are no specific recommendations for thoracic epidural anesthesia, preventing delayed gastric emptying and intestinal paresis in liver surgery.

## 1. Introduction

In recent years, principles of perioperative management have changed enough, as in other fields of medicine. It is known that surgical procedure causes surgical stress disorder, which consists of therapeutic effect, injury, and stress response [1]. One of the principles of preoperative, intraoperative, postoperative management is getting maximal therapeutic effect, and another one is achieving recovery without complication. In the getting maximal therapeutic effect, the right choice of the surgical operation and in the prevention of the complications, impact on the causes and mechanisms play the leading role.

It is also known that the main causes of the postoperative complicated period are operation-related (type of surgery, intraoperative problems, and perioperative management) and patient-related (comorbidities, also muscle weakness) risk factors. There were some changes in the known traditional fundamental theory for the mechanism of complications in recent years. According to the traditional theory of surgical stress, surgical injury activates the survival reactions in the body

(“survival reactions until recovery”) - neuroendocrine response appears, functional and energy reserves are mobilized, a hypermetabolic and hyperfunctional states develop. Complicating factors deplete all reserves, cause decompensation, and as result complications occur [2]. Traditional theory is based on the concept of decompensation and for this theory suppressing reactions, increasing reserves, and replacing functions were accepted as main directions in the treatment of surgical stress for a long time. Following the recent concept, the surgical stress response is not only a survival reaction but also a recovery reaction (“survival and recovery reaction”), and it mobilizes all functional and energy reserves of the body by activating both neuroendocrine and immune reactions [3,4]. Surgery, co-morbidities, and muscle weakness, as well as additional interventions for replacing functions, lead to dysregulation, dysfunction, and decompensation, and by this way, complications occur (Fig. 1). This concept revealed the principle of reducing and regulating the severity of the surgical stress response, instead of suppressing (blocking) and replacing it. Based on this, ERAS (Enhanced Recovery After Surgery) programs have become the main topic of

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perioperative management. The basis of the ERAS concept is reducing the severity of surgical stress response by decreasing the invasiveness of interventions. According to this concept, for decreasing complications and speeding up recovery, reducing the severity of the stress response (not block or replace, but reduce it) is necessary. And for this purpose, to reduce all reactogenic effects, like surgical injury, invasiveness and numbers of interventions is recommended:

Less intervention = less reaction = less complications = faster recovery

Nowadays ERAS protocols are successfully applied in many fields of surgery, including colorectal surgery [5]. In recent years, these principles have been used in liver resection [6], transplantation [7] and pancreato-duodenal surgery [8], and international guidelines have been developed about them. In these guidelines, there are overlapping and non-overlapping, and conflicting items.

This study aimed to identify the different and specific aspects of the protocols with the intent of practical support to hepatopancreatobiliary surgeons.

## 2. Material and methods

In present study, we investigated ERAS protocols for liver resection, liver transplantation, and PD. The recommendations were compared with each other and it was described in Table 1.

## 3. Results

There were 22 recommendations about liver resection, 21 recommendations about liver transplantation, 23 recommendations about PDR. 20 recommendations of them are common, which belong to all 3 operations, and 6 recommendations were specific for each operation.

### 3.1. Preoperative counselling and psychological support

In all three guidelines have been reported that reducing fear and anxiety decreases complications of the operation and for this purpose multidisciplinary support is recommended [6–8]. Before the operation,

the procedure and possible results should be explained to the patient and relatives with a verbal explanation or multimedia tools, and if necessary phycological support should be provided [9–11].

### 3.2. Physical exercises

Some studies have shown that preoperative breathing and physical exercises decrease postoperative lung and thrombotic complications [12,13]. But there is no specific recommendation about the benefits of preoperative physical exercises in pancreatoduodenectomy, liver resection, and liver transplantation [6–8].

### 3.3. Nutritional assessment and support

It is known that nutritional deficiency increases the risk for septic and nonseptic complications after major surgery. In all three guidelines, the nutritional assessment and if necessary nutritional support is highly and strongly recommended [6–8]. Nutritional status can evaluate multidisciplinary. In patients with a nutritional deficiency (last 6 months 10–15% weight loss, BMI <18.5 kg/m<sup>2</sup>, albumin <30 g/l) postponing the operation 2 weeks and providing nutritional support (30–35 kcal/kg/day and 1.5 g/kg/day protein) using enteral (oral, nasogastric tube, nasojejunal tube) methods are recommended. If enteral methods are not possible parenteral methods can be used [12,14,14,15].

### 3.4. Immunonutrition

Some studies showed that oral intake of amino acids, like arginine, glutamine, vitamins, omega-3 fatty acids, and nucleotides positively impact the immune system and decrease postoperative complications [14,16]. But there is no approved recommendation for liver transplantation, liver and pancreas resection [6,7].

### 3.5. Probiotics

Some investigations reported that oral use of probiotics causes

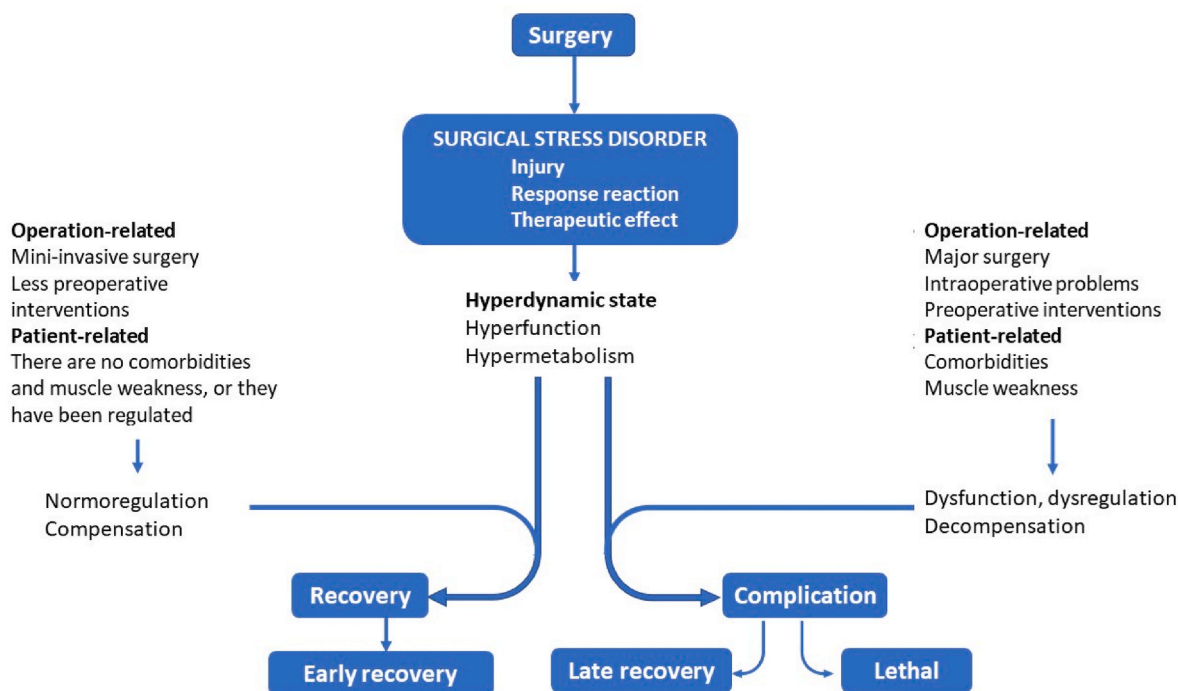


Fig. 1. The course of surgical stress disorder and affecting risk factors.

**Table 1**  
ERAS recommendations in liver resection, liver transplantation and PD.

Item	Liver resection	Liver transplantation	PD
<b>Preoperative items</b>			
Preoperative counselling and psychological support	The procedure and possible results should be explained to the patient and relatives with a verbal explanation or multimedia tools for reducing fear and anxiety (moderate/strong)	The procedure and possible results should be explained to the patient and relatives with a verbal explanation or multimedia tools for reducing fear and anxiety (low/strong)	The procedure and possible results should be explained to the patient and relatives with a verbal explanation or multimedia tools for reducing fear and anxiety (moderate/weak)
Preoperative physical exercises	There is no exact recommendation	There is no exact recommendation	There is no exact recommendation
Preoperative nutritional assessment	Nutritional assessment is recommended. In patients with a nutritional deficiency (last 6 months 10–15% weight loss, BMI <18.5 kg/m <sup>2</sup> , albumin <30 g/l) postponing the operation 2 weeks and providing nutritional support 1 week before the operation is recommended (high/strong)	Nutritional assessment is recommended. In patients with cirrhosis and nutritional deficiency (last 6 months 10–15% weight loss, BMI <18.5 kg/m <sup>2</sup> , albumin <30 g/l) providing 30–35 kcal/kg/day and 1.5 g/kg/day protein is recommended in the preoperative period. (high/strong)	Nutritional assessment and several weeks before the operation nutritional support is recommended (high/strong)
Preoperative immunonutrition	There is no exact recommendation	There is no exact recommendation	There is no exact recommendation
Preoperative probiotics	There is no exact recommendation	There is no exact recommendation	There is no exact recommendation
Smoking and alcohol cessation			For decreasing wound and pulmonary complications at least 4 weeks before the operation smoking cessation is recommended. In addition to this, cessation of excessive alcohol intake is recommended (high/strong)
Preoperative fasting	Excluding patients with gastroduodenal obstruction, diabetes, and neuropathy, the stopping intake of solid foods 6 h before the operation and liquids 2 h before the operation is recommended. (moderate/strong)	Excluding patients with gastroduodenal obstruction, diabetes, neuropathy, and tense ascites the stopping intake of solid foods 6 h before the operation and liquids 2 h before the operation is recommended. (moderate/strong)	Excluding patients with gastroduodenal obstruction, diabetes, and neuropathy, the stopping intake of solid foods 6 h before the operation and liquids 2 h before the operation is recommended. (moderate/strong)
Preoperative intaking carbohydrate-rich drink	The evening before and 2 h before the operation intake of the carbohydrate-rich drink is recommended (excluding patients with gastroduodenal obstruction, diabetes, and neuropathy) (low/weak)	2 h before the operation intake of the carbohydrate-rich drink is recommended (excluding patients with gastroduodenal obstruction, diabetes, and neuropathy) (low/weak)	2 h before the operation intake of the carbohydrate-rich drink is recommended (excluding patients with gastroduodenal obstruction, diabetes, and neuropathy) (moderate/strong)
Antibiotic prophylaxis	Pre- and intraoperative antibiotic prophylaxis is recommended (1 h before the incision and intraoperatively depending on the half-life of the drug once every 3–4 h. In the postoperative period it is not recommended (moderate/strong)	Pre- and intraoperative antibiotic prophylaxis is recommended (1 h before the incision and intraoperatively once every 3–4 h. In the postoperative period it is not recommended (low/weak)	Pre- and intraoperative antibiotic prophylaxis is recommended (1 h before the incision and intraoperatively once every 3–4 h. In the postoperative period, antibiotic prophylaxis in only patients with biliary stent and positive bile culture is recommended
Skin preparation	Alcohol-based antiseptics (chlorhexidine solution 2%, alcohol, povidone-iodine) are recommended. (moderate/strong)	Alcohol-based antiseptics (chlorhexidine solution 2%, alcohol, povidone-iodine) are recommended (moderate/strong)	Alcohol-based antiseptics (chlorhexidine solution 2%, alcohol, povidone-iodine) are recommended (moderate/strong)
Thrombosis prophylaxis	Compression socks and low molecular weight heparin (LMWH, it should be started 2–12 h before the surgery and has continued until exit the hospital, in high-risk patients, it has continued for 4 weeks) are recommended (low/weak)	Compression socks are recommended. Drug therapy depending on thrombo-elastography is recommended. (low/weak)	Compression socks and low molecular weight heparin (LMWH, it should be started 2–12 h before the surgery and has continued until exit the hospital, in high-risk patients, it has continued for 4 weeks) are recommended (high/strong)
Premedication	Avoiding long-acting anxiolytics, use of short-acting anxiolytics in special patient groups, and for analgesia, the use of non-opioid analgesics is recommended (moderate/strong)	Avoiding long-acting anxiolytics, use of short-acting anxiolytics in special patient groups, and for analgesia, the use of non-opioid analgesics is recommended (low/weak)	Avoiding long-acting anxiolytics, use of short-acting anxiolytics in special patient groups, and for analgesia, the use of non-opioid analgesics is recommended (moderate/strong)
<b>Intraoperative items</b>			
Incision	Avoiding Mercedes type incision is recommended (moderate/strong)	Avoiding Mercedes type incision is recommended (moderate/strong)	
Infusion therapy	A goal-directed fluid therapy based on non-invasive monitoring of CVP and cardiac output is recommended.	A goal-directed fluid therapy based on non-invasive monitoring of CVP and cardiac output is recommended.	A goal-directed fluid therapy based on non-invasive monitoring of CVP and cardiac output is recommended.
Normothermia	In intraoperative and early postoperative period providing intraoperative normothermia and avoiding hypothermia are recommended (moderate/strong)	In intraoperative and early postoperative period providing intraoperative normothermia and avoiding hypothermia are recommended (moderate/strong)	In intraoperative and early postoperative period providing intraoperative normothermia and avoiding hypothermia are recommended (moderate/strong)
Abdominal drainage	There is no exact recommendation, however, if it used, it should be early removed as soon as possible (low/weak)	There is no reason for rejection, however, if it used, it should be early removed as soon as possible (low/weak)	If amylase level <5000 U/L during the first 72 h, you should remove it (moderate-strong)
Nasogastric intubation	Postoperative routinely nasogastric intubation is not recommended. (high/strong)	Postoperative routinely nasogastric intubation is not recommended. (high/strong)	Postoperative routinely nasogastric intubation is not recommended. (high/strong)
<b>Postoperative items</b>			
Early extubation	No recommendation	In all patient early extubation (after 3–8 h) should be thought and if it possible is recommended (low/strong)	No recommendation
Antiemetic therapy	In all patients, dual antiemetic therapy (combination of 5HT3 receptor antagonist and	In all patients, dual antiemetic therapy (combination of 5HT3 receptor antagonist and	In all patients, dual antiemetic therapy (combination of 5HT3 receptor antagonist and

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Table 1 (continued)

Item	Liver resection	Liver transplantation	PD
Perioperative analgesia	steroid) is recommended. And if necessary other drugs can be used. (moderate/strong) Intrathecal opioids and peri-incisional catheters are recommended, but TEA is not recommended.	steroid) is recommended. And if necessary other drugs can be used. (low/strong) Multimodal analgesia is recommended. There is not clear recommendation about rejecting opioids. Abdominal block and patient-controlled analgesia are recommended, TEA is not recommended.	steroid) is recommended. And if necessary other drugs can be used. (moderate/strong) Multimodal analgesia is recommended: oral and parenteral non-steroid, patient-controlled opioids and regional anesthesia – peri-incisional infiltration with a local anesthetic, transverse abdominis plane block, thoracic epidural anesthesia
Early activation	In the first postoperative day the activation is recommended (first day 2–4, afterwards 4–6 h). (moderate/strong)	In the first postoperative day the activation is recommended (first day 2–4, afterwards 4–6 h). (moderate/strong)	In the first postoperative day the activation is recommended (first day 2–4, afterwards 4–6 h). (moderate/strong)
Early oral feeding	Early (during 12–24 h) oral feeding is recommended. Enteral and parenteral nutrition is recommended in those who can't tolerate oral feeding (delayed gastric emptying, ileus) and have malnutrition	Early (during 12–24 h) oral feeding is recommended. Enteral and parenteral nutrition is recommended in those who can't tolerate oral feeding (delayed gastric emptying, ileus) and have malnutrition	Early (during 12–24 h) oral feeding is recommended. Enteral and parenteral nutrition is recommended in those who can't tolerate oral feeding (delayed gastric emptying, ileus) and have malnutrition
Glycemic control	Strict glycemic control, correction of hyperglycemia with insulin, and maintaining normoglycemia are recommended. (moderate/strong)	Strict glycemic control, correction of hyperglycemia with insulin, and maintaining a level of glucose at 80–180 mg/dl are recommended (moderate/strong)	Strict glycemic control, correction of hyperglycemia with insulin, and maintaining normoglycemia are recommended. (moderate/strong)
Delayed gastric emptying	In left hemihepatectomy for prevention of delayed gastric emptying omentoplasty is recommended	No recommendation.	Long duration delayed gastric emptying the refusing intraabdominal pathologies and if necessary parenteral nutrition is recommended
Intestinal paresis	Stimulation of bowel movements is not recommended.	No recommendation.	Chewing gum and some prokinetics (mosapride) are recommended, routinely metoclopramide, ghrelin receptor antagonists, dihydroergotamine, neostigmine and erythromycin are not recommended
Audit	Periodically discussion and evaluation are recommended (high/strong)	Periodically discussion and evaluation are recommended (high/strong)	Periodically discussion and evaluation are recommended (high/strong)
<b>Specific items for each operation</b>			
Preoperative steroid	Excluding patients with diabetes, preoperative 30 mg/kg methylprednisolone is recommended. (moderate/weak)		
Portocaval shunt		It depends on the surgeon's choice.	It is not recommended
Ocreotide in PD			Preoperative biliary drainage should not be used routinely, only in special indications: if the bilirubin level is more than 15 mg/dL, if neoadjuvant therapy is required, and if there is cholangitis.
Preoperative biliary drainage in PD			

modulation of gut microbiota, a decrease of bacterial translocation, and as a result decrease of septic complications after bowel operations [17]. But there is no specific recommendation in guidelines about the use of probiotics [6–8].

### 3.6. Smoking and alcohol

Smoking and the use of alcohol can cause lung and wound complications. There is a recommendation only in the guideline about PD. It is recommended that for decreasing wound and pulmonary complications at least 4 weeks before the operation smoking cessation [8,18,19]. In addition to this, cessation of excessive alcohol intake drinking is recommended [8]. But there is no recommendation about the intake of a small amount of alcohol [6–8].

### 3.7. Eating and drinking

Preoperative eating and drinking can result in aspiration during anesthesia. By taking into consideration this, in the classical theory 8–10 h fasting before the operation is recommended [20,21]. However last investigations showed that long-duration hunger and thirst can cause ketogenesis, dehydration, and complications. That's why in all 3 protocols is not recommended preoperative long-duration fasting. It is recommended that excluding patients with gastroduodenal obstruction, diabetes, and neuropathy, preoperative fasting shouldn't be more than 6 h for solid foods, and more than 2 h for liquids [6–8,22].

### 3.8. Intake of the carbohydrate-rich drink

It seems that preoperative oral feeding, as well as, intake of the carbohydrate-rich drink have a positive impact on the functions of the gastrointestinal tract, together with providing mucosal nutrition. Also, it decreases insulin resistance and complications due to surgical stress [23, 24]. In all 3 guidelines 2 h before the operation intake of the carbohydrate-rich drink is recommended (excluding patients with gastroduodenal obstruction, diabetes, and neuropathy) [6–8]. In liver resection also the evening before the operation intake of the carbohydrate-rich drink is recommended [25].

### 3.9. Antibiotic prophylaxis

In hepatopancreatobiliary surgery, one of the most effective methods for the prevention of surgical site infections due to biliary contamination is antibiotic prophylaxis. According to the traditional theory in the preoperative and early postoperative (after a few hours or day) periods, the antibiotic was using. The latest studies reported that the use of single-dose preoperative and intraoperative antibiotic is sufficient for prophylaxis and the use of postoperative antibiotics doesn't impact the incidence of infection [26]. If we consider it, in all 3 guidelines pre- and intraoperative (1 h before the incision and intraoperatively once every 3–4 h [27]) antibiotic prophylaxis is recommended [6–8]. In the postoperative period routinely antibiotic prophylaxis is not recommended. It is used only for special indications (biliary stent, positive bile culture) [26].

### 3.10. Skin preparation

The studies reported that alcohol-based antiseptics (chlorhexidine solution 2%, alcohol, povidone-iodine) are more effective than water-based ones [28,29]. In all 3 guidelines, alcohol-based antiseptics are recommended [6–8].

### 3.11. Thrombosis prophylaxis

Liver resection, liver transplantation, and pancreatoduodenectomy are risk factors for thrombosis, and thromboembolism and prophylactic measures can decrease them [30,31]. Mechanical devices are recommended in all 3 guidelines [6–8]. Low molecular weight heparin (LMWH) is recommended in liver resection and pancreatoduodenectomy: it should be started 2–12 h before the surgery and has continued until exit the hospital, but in patients with risk factors (cancer, thrombophilia) it has continued for 4 weeks [31,32]. The interval between the LMWH injection and epidural catheter placement or removal should be more than 12 h and between the LMWH injection and the blood vessel catheterization should be more than 4 h [33]. In liver transplantation, there is no certain recommendation about prophylactic antithrombotic therapy, and drug therapy depending on thromboelastography is recommended [6–8].

### 3.12. Premedication

Drugs which using in traditional premedication have some side effects, such as postoperative confusion in anxiolytics, and vomiting, nausea, respiratory depression in opioids [34]. By taking into consideration that, in all 3 guidelines the avoiding long-acting anxiolytics, use of short-acting anxiolytics in special patient groups, and for analgesia the use of non-opioid analgesics are recommended [6–8].

### 3.13. Incision

If considering that most common wound complications among 4 incisions (bilateral subcostal, Mercedes type incision, reversed L-shaped, and midline laparotomy) which using in liver resection and transplantation occur after Mercedes type incision [34], the rejecting of this incision is recommended [6–8].

### 3.14. Minimally invasive intervention

It is confirmed by studies that, laparoscopic and robotic approaches decrease postoperative complications. Laparoscopy in the left hemihepatectomy is recommended [35].

### 3.15. Nasogastric intubation

It is known that the using nasogastric tube increases pulmonary complications, causes delaying functions of the gastrointestinal tract, and doesn't decrease anastomosis leakage [36]. That's why in all 3 guidelines routinely nasogastric intubation is not recommended [6–8].

### 3.16. Abdominal drainage

There are some controversial recommendations about the benefits and damages of abdominal drainage in liver surgery. In some studies reported that abdominal drainage decrease bilomas, abscesses, and pancreatic fistulas [37], but on the other hand abdominal drainage increases surgical site infections and pancreatic fistulas [38]. That's why there is no clear recommendation, however, if it used, it should be early removed as soon as possible: if there is no bile secretion or if amylase <5000 U/L during the first 72 h, you should remove it, controversy and if there is refractory ascites you should save it [39,40].

### 3.17. Fluid therapy

One of the main problems of perioperative management in the ERAS guideline is providing normovolemia in central hemodynamics. In intraoperative and early postoperative periods liberal regime and excessive fluid infusion cause interstitial oedema, lung, and anastomosis complications [41], in liver transplantation it causes bleedings [42]. Restrictive fluid therapy increases renal failure risk. That's why in all 3 guidelines goal-directed fluid therapy based on non-invasive monitoring of CBP and cardiac output is recommended [6–8].

### 3.18. Hypothermia

Hypothermia (less than 36 °C degrees) increases bleeding, blood transfusion, arrhythmia, and wound complication [43,44]. In all 3 protocols providing intraoperative normothermia and avoiding hypothermia are recommended [6–8].

### 3.19. Perioperative analgesia

Pain is the main factor which is started surgical stress response and is increased the severity and maximal reducing pain is the main measure in the ERAS guidelines. For this purpose, there are many drugs that, there can be included oral and parenteral nonsteroidal anti-inflammatory drugs (paracetamol, diclofenac, ibuprofen, ketoprofen), opioids (morphine and hydromorphone), non-opioid analgesics (tramadol), local and regional anesthesia (local anesthetic infiltration around the incision, thoracic epidural anesthesia (TEA), transverse abdominis plane (TAP) block, spinal anesthesia). There are some side effects such as in non-steroids platelet and renal dysfunction, in opioids bowel, cognitive, and immune dysfunctions, in epidural analgesia hypotension, ischuria, and epidural bleeding. For decreasing the side effects of epidural anesthesia combination of anesthetic with low dose opioid is recommended. It is reported that there is no difference between the regional anesthesia methods (TEA, TAP, infiltration) for effectiveness. Currently, the main principle in guidelines is the multimodal approach, at the same time use of central and peripheral enteral-parenteral analgesics, as result maximal reducing pain. Almost all known local and regional anesthetics and analgesics in PD are recommended [8]. Thoracic epidural anesthesia is not recommended in liver transplantation and liver resection due to the risk of bleeding [6,7,45].

### 3.20. Prevention of nausea and vomiting

Nausea and vomiting are the most common complications which occur in the early postoperative period (first hours). And usually, it is due to the use of opioids, nasogastric tube, and anesthesia and it can cause electrolyte disbalance, dehydration, and wound complications [41]. That's why in all 3 guidelines the prevention of these complications plays a significant role and in all patients, the dual antiemetic is recommended [6–8]. The most recommended combination is 5HT3 (serotonin) receptor antagonists (ondansetron) and steroids (dexamethasone). If it is required the third antiemetic can be added. And in diabetics steroids can be replaced with histamine blockers and others [46,47].

### 3.21. Glucose control

In major surgery, during intraoperative and early postoperative periods insulin resistance occurs, and glucose level increases due to stress [48]. And hyperglycemia causes wound and infection complications [49]. That's why in all 3 guidelines, strict glucose control, correction of hyperglycemia with insulin, and maintaining a level of glucose at normoglycemia or 80–180 mg/dl are recommended [6–8].

### 3.22. Early oral feeding

Oral feeding is an important measure not for only the treatment and prevention of malnutrition, as well as to repair functions of the gastrointestinal tract and to supply mucosal nutrition. In all 3 guidelines early (during 12–24 h) oral feeding is recommended [6–8]. Enteral and parenteral nutrition is recommended who can't tolerate oral feeding (delayed gastric emptying, ileus) and have malnutrition [22].

### 3.23. Early activation

Bed rest causes complications, such as muscular atrophy, thromboembolism, insulin resistance [50]. In all 3 guidelines, early, namely in the first postoperative day the activation is recommended (first day 2–4, after 4–6 h) [6–8].

### 3.24. Bowel stimulation

Postoperative intestinal paresis is one of the common complications, and it occurs due to peritoneal irritation and pain, electrolyte imbalance, and oedema, also anesthetics and opioids. In liver resection, bowel stimulation is not recommended [6], and in liver transplantation, there is no recommendation [7]. In PD chewing gum and some prokinetics are recommended [8,51,52].

### 3.25. Delayed gastric emptying

Delayed gastric emptying is a complication that occurs after left hemihepatectomy and PD and it can be due to anatomical changes, cutting lesser omentum and nerves, and local complications [6,8,51]. For the prevention of this in liver resection covering resection face with omentum, but in PD protecting lesser omentum are recommended [6, 49]. Long duration delayed gastric emptying you should reject intra-abdominal pathologies and if it is required parenteral nutrition is recommended [8]. There is no recommendation in liver transplantation about it.

### 3.26. Audit

Periodically discussion and evaluation of all activities, as well as, surgical activities help to correct the mistakes, to implement useful measures, so on to increase quality, and to have better outcomes [53]. In all 3 guidelines periodically discussion and evaluation are recommended [6–8].

### 3.27. Use of octreotide in PD

In earlier times, it is believed that octreotide decreases pancreas secretion, as well as pancreatic fistulas after PD. However, the latest studies showed that octreotide doesn't impact seriously postoperative pancreatic fistulas, that's why it is not recommended [54,55].

### 3.28. Preoperative biliary drainage

It is reported that preoperative biliary drainage decreases surgical site infections in pancreas cancer complicated by mechanical jaundice [56,57]. To this respect, in the guideline, it is recommended that preoperative biliary drainage should be used not routinely, only in special indications: if bilirubin levels >15 mg/dL if neoadjuvant therapy is required, and if there is cholangitis [58].

### 3.29. Preoperative steroid therapy

The use of steroids before the liver resection decreases postoperative bilirubin levels, interleukin, and complications [33]. To this respect, a patient who has normal parenchyma preoperatively giving 30 mg/kg

methylprednisolone is recommended. In diabetics, it is not recommended [6]. The giving preoperative steroid is a component of standard immunosuppression in LTx [7]. But in PD there is no information [8].

## 4. Discussion

After the comparative analyses, the items were classified into 5 groups to provide the practical benefits of recommendations and easy remembering [6–8].

The first group included 17 items, which are recommended for all 3 groups [9,26,59,60] (of course, if there is no contraindication) and they are shown below:

- Preoperative counselling and psychological support
- Preoperative nutritional support
- Smoking and alcohol cessation
- Pre- and intraoperative antibiotic prophylaxis
- Mechanical devices for thrombosis prevention
- Limiting of preoperative fasting to 2 h for liquids and to 6 h for solid foods
- Preoperative intaking carbohydrate-rich drink
- Alcohol-based antiseptics for skin preparation
- Goal-directed infusion therapy which based on monitoring
- Providing normothermia
- Early removal of the abdominal drainage tube
- Glycemic control
- Dual antiemetic therapy for preventing nausea and vomiting
- Perioperative multimodal analgesia strategies (local-regional and central)
- Early oral feeding
- Early activation
- Audit

The second group included 3 items, which are recommended for only special patient groups [6,59] and they are shown below:

- Postoperative antibiotic prophylaxis – it was recommended for most of the patients in the past, however, in these guidelines, it is recommended only for special indications (biliary stent, positive bile culture).
- Enteral and parenteral nutrition – it is recommended who can't tolerate oral feeding and have malnutrition as the second choice
- Short-acting anxiolytics – it was recommended for all patients in the past, however in this guidelines it is recommended only patients who require intervention before the anesthesia (for example, TEA)

The third group included 3 items, which are rejected in all 3 groups and they are as follows:

- Mercedes type incision – it is not recommended due to the high risk of wound complication.
- Long-acting anxiolytics – as it has no significant benefits and it causes postoperative cognitive dissonance, it is not recommended.
- Postoperative nasogastric intubation – it is not recommended due to increasing pulmonary complications, and delaying functions of the gastrointestinal tract.

The fourth group included controversial recommendations [8,9]:

- Preoperative physical exercises
- Preoperative immunonutrition
- Preoperative probiotics

In the fifth group specific recommendations for all three operations are included:

- Thoracic epidural anesthesia – it is recommended in PD, but in liver resection and transplantation it is not recommended due to the risk of bleeding.
- Preventing delayed gastric emptying – for prevention of delayed gastric emptying omentoplasty is recommended in liver resection, but in other groups, there is no recommendation.
- Intestinal paresis – There is not clearly recommendation for preventing intestinal paresis.

## 5. Conclusion

Thereby, in perioperative care after liver resection, transplantation and pancreatoduodenectomy, ERAS recommendations are based on the reducing invasiveness of procedures and the severity of the surgical stress, which results in decreasing complications and enhanced recovery. Recommendations for all three operations can be classified into five groups: recommended for all patients, recommended for special patient groups, rejected for all patients, controversial recommendations, specific recommendations for all three operations.

## Ethical approval

Not applicable, because this article does not contain any studies with human or animal subjects.

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## Author contribution

**Nuru Bayramov:** Conceptualization, Validation, Resources, Writing - original draft, **Shabnam Mammadova:** Writing - review & editing, Visualisation.

## Research registration Unique Identifying number (UIN)

1. Name of the registry:
2. Unique Identifying number or registration ID:
3. Hyperlink to your specific registration (must be publicly accessible and will be checked):

## Guarantor

Nuru Bayramov.

## Declaration of competing interest

No conflicts of interest to disclose.

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