Review Article

Enhanced recovery after surgery for liver resection surgery

Katie Wimble, Chris Jones

Department of Anaesthetics, Surrey Peri-operative Anaesthesia and Critical Care Collaborative Research Group (SPACeR), Royal Surrey County Hospital, Guildford, Surrey, UK

Contributions: (I) Conception and design: All authors; (II) Administrative support: All authors; (III) Provision of study material or patients: All authors; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Katie Wimble. Registrar, Royal Surrey County Hospital NHS Foundation Trust, Guildford, Surrey GU2 7XX, UK.
Email: katie.wimble@nhs.net.

Abstract: Enhanced recovery after surgery (ERAS) programmes were first described in colorectal surgery in the 1990s and since then the core principles have been utilised in many major surgical groups with adaptations being tailored to the specific surgery. The overall aim is to reduce length of stay and complications whilst improving patient satisfaction and long-term outcomes. Liver surgery is high risk and there are important considerations that need to be appreciated to guide the perioperative care of these patients. ERAS for liver surgery has been shown to be safe and efficacious when compared to traditional management and ongoing research is now focusing on improving outcomes further through optimal analgesia, nutrition and perioperative care.

Keywords: Enhanced recovery after surgery (ERAS); liver; analgesia

Received: 28 July 2019; Accepted: 15 August 2019; Published: 09 September 2019.
doi: 10.21037/dmr.2019.08.04
View this article at: http://dx.doi.org/10.21037/dmr.2019.08.04

Introduction

Enhanced recovery after surgery (ERAS) programmes were first described by a Danish surgeon, Professor Henrik Kehlet, in patients undergoing colorectal surgery and he showed how an ERAS approach led to reduced complications, costs and length of stay with improved patient satisfaction. The approach uses evidence-based practices aimed at reducing the surgical stress response leading to quicker recovery time and improved oncological outcomes (1). Since the advent of ERAS programmes the principles have been extrapolated to multiple patient groups undergoing elective and emergency surgery and has been shown to be safe, effective and feasible (2).

Liver resection surgery is high risk but an improved understanding of anatomy and physiology as well as advances in surgical and anaesthetic techniques have significantly improved outcomes over the last 50 years. The perioperative mortality for patients undergoing elective liver resections is now quoted to be around 3% (3) within high volume institutions.

Colorectal metastases remain the most common indication for liver resections with 25% of patients having liver metastases at diagnosis and many more developing metastatic disease after colorectal resection. Liver resection with neoadjuvant chemotherapy for colorectal metastases has been shown to give an overall 5-year survival of approximately 46.1% with 27.9% being disease free at 5 years (4) compared with only negligible survival in those left untreated (3).

Since the introduction of ERAS programmes for liver surgery there have been few randomized controlled trials (RCTs) which have looked at the safety and efficacy of ERAS compared with traditional management. An ongoing concern is that ERAS programmes may lead to quicker discharge but at the expense of increased readmission rates. Prior to 2016 there weren't any consensus guidelines with reference to ERAS for liver surgery and centres were commonly using their own interpretation of the work which had been focused on colorectal surgery. A metanalysis in

2016 sought to look at all RCTs and assess whether ERAS programmes were safe and effective in liver resection surgery (5). Six hundred and thirty-four patients were looked at across 4 studies, 399 received ERAS care and 325 received standard care. Only one study reported on mortality during their study (6) but showed no difference between the groups. Overall morbidity was less in the ERAS groups but there were no significant differences between major and minor complications between the groups (5). They concluded that ERAS programmes were therefore safe and do not lead to increased complication rates. Readmission rates were no different between groups and it was felt that ERAS programmes may accelerate postoperative recovery as seen by faster returns to functional recovery in the ERAS groups (5).

In order to achieve these favourable outcomes, there needs to be effective collaboration between surgeons, anaesthetists, intensivists, nursing staff and allied health professionals throughout the whole perioperative journey. We will explore how an enhanced recovery pathway is tailored to patients undergoing liver resection.

Preoperative assessment

This is a key time for ensuring patients are appropriately worked up for surgery and should herald the beginning of the patient education pathway which has been shown to improve overall outcomes. Patients should be educated about what to expect from the entire perioperative episode, this includes surgical, anaesthetic and nursing considerations. Motivated and educated patients are more likely to adhere to prescribed protocols if they are aware of the benefits and empowered to help shape and improve their outcomes. Written information detailing what the patient should expect should be given at pre-assessment (7).

Patients suitable for management on an ERAS pathway should be identified early with preassessment focusing on a tailored approach whilst identifying any barriers to this process. There are no absolute contraindications to patients being managed on an ERAS protocol but resistance from frontline clinicians, resource scarcity for implementation and patient complexity have been identified as potential obstacles (8). It is therefore paramount that all stakeholders are on board with the ERAS philosophy. Many patients will have had previous bowel resections which can make subsequent surgery more challenging. Patients may also have had chemotherapy or radiotherapy as adjuvant therapy, any side effects of this should be identified as should any deleterious effects on cardiorespiratory reserve.

The lead in time from diagnosis to surgery is often limited but it is important that medical conditions are appropriately optimised and specialist input sought if needed. Patients presenting for liver resection are likely to have comorbidities and as with all elective surgical interventions medical optimisation is vital to minimise perioperative morbidity and mortality.

Assessment of liver reserve is key to planning liver resections in order to reduce the incidence of post-operative liver failure. Child-Pugh classification, extent and location of lesion and indocyanine green retention rates are used to assess liver function and calculate the minimum volume of liver that must remain in order to maintain the physiological function of the liver (9).

All patients should be screened for malnutrition at pre-assessment, there are many validated approaches to this including the MUST screening tool (Malnutrition Universal Screening Tool) (10). Malnutrition is associated with poor post-operative outcomes so patients with weight loss or at risk of malnutrition should be identified and if necessary additional nutrition should be commenced and surgery should be postponed allowing patients to gain weight particularly if >10% weight loss has been reported (11).

Prehabilitation is growing in popularity as it has been shown to improve the preoperative clinical reserve and thus lead to reduced post-operative complications (12).

With an ever-ageing population there are concerns around frailty and its effects on patient outcome. Baseline serum albumin, age and sarcopenia have all been associated with postoperative morbidity (13). Identifying patients with frailty or those at risk of frailty should allow for tailoring of care surrounding the operative period.

Peri-operative care

Fasting

The traditional approach to pre-operative fasting has seen a dramatic change in recent years. It is still accepted that patients stop eating a light diet 6 hours prior to induction of anaesthesia but now patients are actively encouraged to drink clear fluids up until 2 hours before to try and maintain euvolaemia, ensure patient comfort and avoid electrolyte imbalances. The use of routine bowel preparation is rapidly dwindling and there is currently no role for this within isolated liver resections. Carbohydrate pre-loading has been shown to reduce insulin resistance and catabolism

as well as aid in preservation of muscle strength (14). A typical ERAS regime involves giving 800 mL containing 100 g carbohydrate 12 hours prior to surgery and 400 mL containing 50 g carbohydrate 2 hours prior to surgery for maximum benefit (14); this improves patient comfort and wellbeing as well as delivering the patients to theatre in a metabolically fed state.

Anaesthetic technique

There have been no studies to date showing that one anaesthetic technique is superior to another and the choice lies with the anaesthetist in charge of the case. In general, long acting agents should be avoided in order to achieve a clear-headed emergence from anaesthesia with adequate pain relief, the avoidance of postoperative nausea and vomiting, and ensuring patients are euvolaemic and normothermic (15).

Infection control

A single dose of prophylactic antibiotics is required within 1 hour of skin incision, this should follow local protocols but second generation cephalosporins such as cefuroxime are commonly used (16). Re-dosing should occur in prolonged surgery beyond 4 hours or in the face of significant blood loss >1,500 mL (16).

Thromboprophylaxis

Aggressive thromboprophylaxis should be instigated, patients with a history of malignancy are at much higher risk of a perioperative thromboembolic event. All patients should receive both thromboembolic stockings, intermittent pneumatic devices and pharmacological prophylaxis unless there are absolute contraindications. Deranged clotting is common following liver resection but a raised international normalised ratio (INR) has been shown to be associated with increased risk of thrombosis therefore heparin-based prophylaxis should only be withheld if there are concerns about surgical haemostasis (17).

Temperature control

Avoidance of hypothermia is of importance in patients undergoing liver resection as hypothermia can lead to impaired coagulation, increased cardiovascular events and increased rates of infection post-operatively. The use of active patient warming devices and warmed intravenous fluids has been shown to reduce postoperative complications and improve patient recovery (6). As with all major surgical procedures close attention should be paid to pressure points and maintaining normoglycemia.

Fluid management

The liver is a highly vascular organ receiving 25% of the cardiac output with approximately 75% coming from the portal vein and 25% from the hepatic artery. It follows that surgery on the liver can be associated with major blood loss. Techniques to minimise central venous pressure and thus portal pressures are commonly used to help minimise blood loss during liver resections. These include the use of glyceryl trinitrate, frusemide, sympathetic blockade via a neuraxial technique, opioid infusions such as remifentanil and fluid restriction until the parenchymal resection is complete. All these agents also work on the arterial system to some extent so need to be counteracted with peripheral vasopressors such as phenylephrine or noradrenaline infusions in order to maintain adequate perfusion pressures. The current consensus is to keep the central venous pressure (CVP) <5 cmH_2O in order to minimise blood loss during parenchymal resection and then resuscitate with balanced crystalloids using goal directed fluid therapy (18). Blood transfusion rates are relatively low given the modern methods employed to reduce blood loss, fluid restriction can mask a fall in haemoglobin concentration so close attend to ongoing blood loss is essential in maintaining adequate oxygen delivery. Tranexamic acid and vitamin K are often given at induction of anaesthesia to help minimise blood loss.

Analgesic strategy

Effective analgesia is paramount when it comes to managing patients and leads to shorter length of stay and fewer post-operative complications. Traditional open approaches involve a significant abdominal incision and are associated with considerable post-operative pain. There are currently major concerns about opioid usage and dependence on a global scale and steps to minimise their usage has been a major topic of concern. There are also concerns that opioids may play a role in disease progression and augmenting cancer biology (19), it follows that multimodal analgesic regimes should be employed wherever possible. Opioid sparing techniques are favoured as they are associated with more rapid return to normal bowel function and less respiratory side effects. Paracetamol and non-steroidal

anti-inflammatory drugs should be given regularly post-operatively if there are no contraindications. The use of gabapentin or pregabalin peri-operatively have been shown to reduce rates of chronic pain and opioid usage (20) and despite pre-medications not being advocated in ERAS protocols many centres do prescribe these peri-operatively. Tramadol, as a weak opioid, has been included in many ERAS protocols for its strong opioid sparing effect in conjunction with simple analgesics. Reports show that these are generally well tolerated in all age groups (21).

Regional techniques form the mainstay in providing analgesia in open liver resections. Studies have repeatedly shown that epidurals can be safely and effectively used to provide analgesia in open liver resections (22). It followed that thoracic epidurals were the gold standard for many years, however, concerns about their side effects and high failure rates has led to a search for other options.

Patients managed with intrathecal morphine and a fentanyl patient-controlled analgesia (PCA) had significantly shorter length of stay compared with those with a thoracic epidural (23) but length of surgery and intraoperative blood loss was greater in the intrathecal group. Initial pain scores were significantly less in the epidural group but beyond this patient satisfaction and pain scores were equivalent (23), and recent evidence has been equivocal when comparing these with intrathecal morphine (24).

Thoracic epidurals have been associated with higher rates of hypotension and thus a greater need for vasopressor support due to sympathetic blockade (25). They can be associated with increased intravenous fluid usage which may have effects on intestinal oedema leading to delayed bowel function post-operatively. The assumed ability of an epidural to attenuate the stress response to surgery and their ability to reduce CVP intraoperatively has led to them being favoured by many for years and these remain strong reasons as to why they are still used in many centres worldwide. Emerging evidence has shown that this may not be the case with studies showing equivocal inflammatory mediator levels and CVP reduction between thoracic epidurals and continuous wound infiltration (26). Most patients presenting for surgery will have normal coagulation studies, close attention must be paid to those with underlying liver disease. Most patients will develop of a degree of coagulopathy after liver resection and this can lead to delayed removal of epidural catheters and concerns over increased complication rates (25).

Wound catheters and peripheral regional anaesthetic techniques offer an alternative solution to help reduce opioid usage and have been shown to lead to equivocal lengths of stay when compared with thoracic epidurals (21). One study looked at replacing the traditional thoracic epidural with transverse abdominal plane (TAP) blocks placed by the surgeon at the end of surgery as part of a wider implementation of an ERAS approach in all open liver resections. They found that the rates of PCA usage increased significantly and that patients were started on narcotics a day earlier in those with TAP blocks (27). Uncontrolled pain was similar in both groups on days 1 and 2 postoperatively but lower in the TAP group on day 3, they do suggest that this may be related to starting narcotics earlier (27). They observed lower rates of intensive care unit (ICU) admission after the implementation of the ERAS protocol but it unclear if this is a direct result of switching from a thoracic epidural to TAP blocks. Hypotension rates were significantly lower after ERAS implementation but there were no differences in the total amount of intravenous fluids, vasopressor use or blood transfusions between the two groups (27).

Continuous wound catheters have been shown to give a faster functional recovery compared with thoracic epidurals with less time spent in high-dependency unit (HDU) and no significant difference in pain scores (26). Interestingly they showed no difference in levels of pro-inflammatory mediators between the two groups (26). A further study looking at epidural vs wound catheter with a PCA showed no difference in length of stay but significantly more vasopressor usage in those managed with epidurals (28). They demonstrated a significant opioid sparing effect of using a wound catheter in combination with a PCA with less failure rates than an epidural (28).

Paravertebral blocks have been compared with thoracic epidurals and were found to be inferior when comparing pain scores up to 48 hours post-operatively but may have a role if there is concerns over coagulation (29).

It has been shown that a multimodal PCA regime (dexamethasone/paracetamol/ketorolac/oxycodone/ketobemidone PCA/wound infiltration) is non inferior to a multimodal thoracic epidural regime (dexamethasone/paracetamol/oxycodone/epidural levobupivacaine and fentanyl) in terms of pain scores during the first 6 days post-operatively with shorter inpatient stays and lower overall opioid usage in those managed with the multimodal PCA regime (Hausken 2019, unpublished data).

Minimally invasive techniques are associated with lower postoperative pain scores and can be managed with a single intrathecal opioid dose or traditional intravenous opioids.

Nasogastric tubes and drains

In agreement with all current ERAS guidelines the use of routine nasogastric tubes is discouraged (11). They are associated with greater pulmonary complications and delayed return of normal gastric function. Abdominal drains also hinder prompt recovery and their routine use is not advised. Urinary catheters should be removed as soon as possible after surgery to encourage mobilisation and minimise infection risks.

Antiemetics

A combination of antiemetics should be used to try and minimise post-operative nausea and vomiting (PONV) as this leads to faster return to enteral intake, it is also associated with greater patient comfort and a quicker return of normal bowel function. Most centres advocate the use of a 5-HT3 receptor antagonist along with glucocorticoids.

Surgical technique

The overall aim is to excise the diseased area with preservation of liver function, minimal blood loss and appropriate oncological clearance. The choice between an open or a laparoscopic approach is dependent on multiple factors, surgical factors include the location and extent of liver lesion, surgical expertise and previous surgical interventions. Patient factors such as significant cardiovascular or respiratory disease may favour either an open or laparoscopic approach depending on the nature and severity of disease. A multidisciplinary approach when planning surgery should take place to ensure the best outcome for patients. Minimally invasive techniques have shorter recovery times and are associated with less pain postoperatively and have not been shown to compromise oncological resection (30). Robotic liver resections are in their infancy and there is no evidence to support their use currently.

Pringle manoeuvre

This surgical technique is used to control bleeding from the liver by intermittently clamping the hepatic pedicle containing the hepatic artery and the portal vein. This can lead to significant cardiovascular compromise due to a decrease in cardiac output and an increase in left ventricular afterload. Effective communication between the surgical and anaesthetic team is vital if this manoeuvre is used.

Postoperative care

Nutrition

Enteral nutrition should be resumed as soon as feasibly possible after surgery. The use of artificial enteral or parenteral nutrition should be reserved for only specific cases where there is prolonged post-operative ileus or concerns over malnutrition. Unless there are absolute contraindications most patients can resume a normal diet on the day of surgery and should be encouraged to do so. This leads to improved patient comfort and has been shown to cause quicker return to normal bowel function with no increase in complication rates (31). Intravenous fluids are rarely required once oral intake has resumed and therefore should be discontinued as soon as possible to avoid fluid overload.

Ambulation

Early ambulation is a key component of ERAS protocols and is associated with reduced rates of ileus, pulmonary complications and thromboembolic events (11). Mobilisation helps to minimise decline in muscle strength and leads to improved patient satisfaction. Patient education at the pre-assessment visit prepares patients for what to expect and ensure better adherence with early post-operative mobilisation. Abolishing the routine use of nasogastric tubes and abdominal drains has meant that mobilisation straight after surgery is not just desirable but achievable.

Complication rates

Complication rates have historically been quoted as affecting nearly all patients (21), albeit many were only minor, but since the introduction of ERAS overall complications have significantly reduced (2). Despite the introduction of ERAS principles, studies have shown that minor complications still affect over 40% of patients, but fortunately they have not been shown to cause any delay in discharge (21). A concern over prompt discharges is that this may lead to increased readmission rates but this has been shown in multiple studies not be to be the case (2,6).

Cost implications

ERAS protocols have been shown to significantly reduce cost of inpatient care across all areas and in particular

medication and laboratory costs (32). Decreased need for ICU beds, radiological investigations, medications and overall length of stay have been shown in multiple studies (33). Meta-analyses looking at the effect of an ERAS protocol on length of stay has shown a weighted mean difference of –2.72 days in those in the ERAS groups (2).

Oncological outcomes

The majority of liver resections are for malignant processes and a recent area of interest has looked at return to intended oncological therapy (RIOT). This looks at the number of patients who initiate postoperative adjuvant therapy of any kind divided by the number intended to receive it, this allows for direct comparisons of surgical procedures and acts as a surrogate for functional recovery (34). Initial reports have shown that minimally invasive techniques and lower complication rates are associated with a higher RIOT rate. It follows that patients managed on ERAS protocols should have higher RIOT rates and centres are being encouraged to report on this important metric (34).

Surgical stress response

There are concerns over the effects that the surgical stress response has on recovery from surgery and cancer recurrence. Multimodal interventions have been known for many years to help reduce the adverse sequelae of major surgery and an understanding of the underlying pathophysiology of the surgical stress response is essential (35). Measures to reduce the stress response include the use of adequate analgesia and minimally invasive surgery. The levels of CRP measured after surgery were found to be lower in the ERAS groups (2) suggesting a positive effect on reducing the surgical stress response.

Conclusions

ERAS for liver resection surgery has been shown to be both safe and effective and has led to reduced inpatient stay with no increase in readmission rates (5). Evidence is continuing to evolve with regards to the optimal analgesic technique in this specialist patient group and it is likely that we may see a reduction in the use of epidurals in the future as the use of minimally invasive surgical techniques increases and evidence of equivocal analgesia with fewer failure rates continue to emerge. Liver resections should be performed at specialist centres and ongoing audit of outcomes and adherence to ERAS protocols is important in ensuring the continued safety and efficacy of such programmes. RIOT rates should be added to traditional metrics as a more up to date method of measuring functional recovery.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *Digestive Medicine Research* for the series "Enhanced Recovery After Surgery (ERAS) Program in General Surgery". The article has undergone external peer review.

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/dmr.2019.08.04). The series "Enhanced Recovery After Surgery (ERAS) Program in General Surgery" was commissioned by the editorial office without any funding or sponsorship. CJ served as the unpaid Guest Editor of the series and serves as the unpaid Associate Editor-in-Chief of *Digestive Medicine Research*. CJ also is an appointed committee officer to the ERAS Society. KW has no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Wilmore DW, Kehlet H. Management of patients in fast track surgery. BMJ 2001;322:473-6.
2. Li L, Chen J, Liu Z, et al. Enhanced recovery program

versus traditional care after hepatectomy: A meta-analysis. Medicine (Baltimore) 2017;96:e8052.
3. Simmonds PC, Primrose JN, Colquitt JL, et al. Surgical resection of hepatic metastases from colorectal cancer: a systematic review of published studies. Br J Cancer 2006;94:982-99.
4. Karanjia ND, Lordan JT, Fawcett WJ, et al. Survival and recurrence after neo-adjuvant chemotherapy and liver resection for colorectal metastases: a ten year study. Eur J Surg Oncol 2009;35:838-43.
5. Song W, Wang K, Zhang RJ, et al. The enhanced recovery after surgery (ERAS) program in liver surgery: a meta-analysis of randomized controlled trials. Springerplus 2016;5:207.
6. Jones C, Kelliher L, Dickinson M, et al. Randomized clinical trial on enhanced recovery versus standard care following open liver resection. Br J Surg 2013;100:1015-24.
7. Gustafsson UO, Scott MJ, Schwenk W, et al. Guidelines for perioperative care in elective colonic surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. Clin Nutr 2012;31:783-800.
8. Stone AB, Yuan CT, Rosen MA, et al. Barriers to and Facilitators of Implementing Enhanced Recovery Pathways Using an Implementation Framework: A Systematic Review. JAMA Surg 2018;153:270-9.
9. Chen L, Wang G, Yang Y. Research progress of staged hepatectomy combined with hepatic disconnection and portal vein ligation. Chinese Journal of Hepatic Surgery 2017;6:71-4.
10. Chao PC, Chuang HJ, Tsao LY, et al. The Malnutrition Universal Screening Tool (MUST) and a nutrition education program for high risk cancer patients: strategies to improve dietary intake in cancer patients. Biomedicine (Taipei) 2015;5:17.
11. Melloul E, Hübner M, Scott M, et al. Guidelines for Perioperative Care for Liver Surgery: Enhanced Recovery After Surgery (ERAS) Society Recommendations. World J Surg 2016;40:2425-40.
12. Wynter-Blyth V, Moorthy K. Prehabilitation: preparing patients for surgery. BMJ 2017;358:j3702.
13. Valero V 3rd, Amini N, Spolverato G, et al. Sarcopenia adversely impacts postoperative complications following resection or transplantation in patients with primary liver tumors. J Gastrointest Surg 2015;19:272-81.
14. Scott MJ, Fawcett WJ. Oral carbohydrate preload drink for major surgery - the first steps from famine to feast. Anaesthesia 2014;69:1308-13.
15. Feldheiser A, Aziz O, Baldini G, et al. Enhanced Recovery After Surgery (ERAS) for gastrointestinal surgery, part 2: consensus statement for anaesthesia practice. Acta Anaesthesiol Scand 2016;60:289-334.
16. Jia W, Liu W, Qiao X. Chinese Expert Consensus on Enhanced Recovery After Hepatectomy (Version 2017). Asian J Surg 2019;42:11-8.
17. Mallett SV, Sugavanam A, Krzanicki DA, et al. Alterations in coagulation following major liver resection. Anaesthesia 2016;71:657-68.
18. Zhao Y, Yang Y, Lou W, et al. Expert Consensus on perioperative fluid therapy in surgical patients. Chin J Pract Surg 2015;35:960-6.
19. Lennon FE, Moss J, Singleton PA. The μ-opioid receptor in cancer progression: is there a direct effect? Anesthesiology 2012;116:940-5.
20. Clarke H, Bonin RP, Orser BA, et al. The prevention of chronic postsurgical pain using gabapentin and pregabalin: a combined systematic review and meta-analysis. Anesth Analg 2012;115:428-42.
21. Savikko J, Ilmakunnas M, Mäkisalo H, et al. Enhanced recovery protocol after liver resection. Br J Surg 2015;102:1526-32.
22. Allen S, DeRoche A, Adams L, et al. Effect of epidural compared to patient-controlled intravenous analgesia on outcomes for patients undergoing liver resection for neoplastic disease. J Surg Oncol 2017;115:402-6.
23. Kasivisvanathan R, Abbassi-Ghadi N, Prout J, et al. A prospective cohort study of intrathecal versus epidural analgesia for patients undergoing hepatic resection. HPB 2014;16:768-75.
24. Koea JB, Young Y, Gunn K. Fast track liver resection: the effect of a comprehensive care package and analgesia with single dose intrathecal morphine with gabapentin or continuous epidural analgesia. HPB Surg 2009;2009:271986.
25. Tzimas P, Prout J, Papadoppoulos G, et al. Epidural anaesthesia and analgesia for liver resection. Anaesthesia 2013;68:628-35.
26. Hughes MJ, Harrison EM, Peel NJ, et al. Randomized clinical trial of perioperative nerve block and continuous local anaesthetic infiltration via wound catheter versus epidural analgesia in open liver resection (LIVER 2 trial). Br J Surg 2015;102:1619-28.
27. Thornblade LW, Seo YD, Kwan T, et al. Enhanced Recovery via Peripheral Nerve Block for Open Hepatectomy. J Gastrointest Surg 2018;22:981-8.
28. Bell R, Ward D, Jeffery J, et al. A Randomized

Controlled Trial Comparing Epidural Analgesia Versus Continuous Local Anesthetic Infiltration Via Abdominal Wound Catheter in Open Liver Resection. Ann Surg 2019;269:413-9
29. Schreiber KL, Chelly JE, Lang RS, et al. Epidural Versus Paravertebral Nerve Block for Postoperative Analgesia in Patients Undergoing Open Liver Resection: A Randomized Clinical Trial. Reg Anesth Pain Med 2016;41:460-8.
30. Yin Z, Fan X, Ye H, et al. Short- and long-term outcomes after laparoscopic and open hepatectomy for hepatocellular carcinoma: a global systematic review and meta-analysis. Ann Surg Oncol 2013;20:1203-15.
31. Lassen K, Kjaeve J, Fetveit T, et al. Allowing normal food at will after major upper gastrointestinal surgery does not increase morbidity: a randomized multicenter trial. Ann Surg 2008;247:721-9.
32. Jing X, Zhang B, Xing S, et al. Cost-benefit analysis of enhanced recovery after hepatectomy in Chinese Han population. Medicine (Baltimore) 2018;97:e11957.
33. Joliat GR, Labgaa I, Hübner M, et al. Cost-Benefit Analysis of the Implementation of an Enhanced Recovery Program in Liver Surgery. World J Surg 2016;40:2441-50.
34. Aloia TA, Zimmitti G, Conrad C, et al. Return to intended oncologic treatment (RIOT): a novel metric for evaluating the quality of oncosurgical therapy for malignancy. J Surg Oncol 2014;110:107-14.
35. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. Br J Anaesth 1997;78:606-17.

doi: 10.21037/dmr.2019.08.04
Cite this article as: Wimble K, Jones C. Enhanced recovery after surgery for liver resection surgery. Dig Med Res 2019;2:22.