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Is Current Perioperative Practice in Hepatic Surgery Based on Enhanced Recovery After Surgery (ERAS) Principles?

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Abstract
Background The worldwide introduction of multimodal enhanced recovery programs has also changed perioperative care in patients who undergo liver resection. This study was performed to assess current perioperative practice in liver surgery in 11 European HPB centers and compare it to enhanced recovery after surgery (ERAS) principles.
Methods In each unit, 15 consecutive patients ($N = 165$) who underwent hepatectomy between 2010 and 2012 were retrospectively analyzed. Compliance was classified as "full," "partial," or "poor" whenever ≥80, ≥50, or <50 % of the 22 ERAS protocol core items were met. The primary study end point was overall compliance with the ERAS core program per unit and per perioperative phase.
Results Most patients were operated on for malignancy (91 %) and 56 % were minor hepatectomies. The median number of implemented ERAS core items was 9 (range = 7–12) across all centers. Compliance was partial in the preoperative (median 2 of 3 items, range = 1–3) and perioperative phases (median 5 of 10 items, range: 4–7). Median postoperative compliance was poor (median 2 of 9 items, range = 0–4). A statistically significant difference was observed between median length of stay and median time to recovery (7 vs. 5 days, $P < 0.001$).

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Conclusion Perioperative care among centers that perform liver resections varied substantially. In current HPB surgical practice, some elements of the ERAS program, e.g., preoperative counselling and minimal fasting, have already been implemented. Elements in the perioperative phase (avoidance of drains and nasogastric tube) and postoperative phase (early resumption of oral intake, early mobilization, and use of recovery criteria) should be further optimized.

Introduction

A multimodal enhanced-recovery perioperative care program for elective abdominal surgery was introduced by Kehlet et al. [1] at the end of the last century. The enhanced-recovery concept combines several evidence-based aspects of perioperative care into a structured care pathway, thereby enabling accelerated postoperative recovery and potentially reducing postoperative morbidity. Within the surgical community, several groups, such as the international enhanced recovery after surgery (ERAS) collaboration, have embraced and studied the enhanced-recovery concept. This led to the successful introduction of a new standard in perioperative care for colorectal surgery patients [2]. In recent years the same principles have also been applied in the perioperative care of liver surgery patients, and a few studies have shown that the program is feasible, safe, and effective for resection of hepatic tumors [3–10].

Actual data on the status of current practice and whether multimodal clinical pathways in liver surgery have been implemented are scarce. Over time, several elements of the ERAS concept have probably been introduced without implementation of a fully formal enhanced-recovery program. A recent survey in the international HPB community showed marginal implementation of ERAS protocols worldwide [11]. Based on the successful introduction and implementation of ERAS programs in various fields of surgery [12–17] and promising results in hepatic surgery, further dissemination of the ERAS concept within the liver surgical field seems desirable. First, to accelerate recovery and reduce length of hospital stay, it is necessary to aim for uniform and evidence-based perioperative management. Moreover, a structured and detailed program with well-defined recovery and discharge criteria can improve comparability of clinical outcomes in clinical audits and future clinical trials. Finally, it is likely that implementation will have a synergetic effect with minimally invasive surgery, as shown in colorectal surgery [18].

It has been suggested that implementation of a structured enhanced-recovery program in liver surgery is hard to achieve since multidisciplinary involvement is essential [19]. However, surgical practice has changed over the years and many ERAS elements may have already been introduced in current practice. Therefore, following an initial electronic survey [11], the aim of this study was to more accurately evaluate current perioperative care by assessing to what extent the different elements of an ERAS program have been implemented in liver surgery in a group of expert HPB units in Europe.

Methods

Study design

A retrospective analysis of prospectively collected data was conducted to assess current perioperative practice in patients undergoing liver surgery in a number of expert HPB centers in Europe. Fifteen consecutive patients per center were assessed. All available medical records (patient and nursing charts, surgery and anesthesia reports) for the different elements in the pre-, intra-, and postoperative phases of admission were reviewed and evaluated using a detailed baseline checklist that consisted of the previously described ERAS elements [4]. This checklist (see the Appendix) was further developed and adjusted by two hepatic surgeons (RMvD, CHCD) and two researchers (EMWLH, LH). Primary study endpoints were overall compliance with the ERAS core program per unit and per element. Secondary endpoints were day of discharge and time to functional recovery (FR).

ERAS elements and compliance

The program's core elements are displayed in Table 1 and are grouped as pre-, peri- (day of surgery), and postoperative elements. If an element in the checklist was marked as "yes," the hospital was able to apply the ERAS element for a particular patient. Details explaining (non)compliance were also added to the "Comments" section of the checklist. Compliance was defined as the degree to which individual units or elements were in accordance with the ERAS program. Units were classified as "fully," "partially," or "poorly" compliant whenever $\geq$80, $\geq$50, or $<$50 %, respectively, of the assessed 22 ERAS core items were met. Per individual element, an 80 % cutoff value was set to qualify a unit as "compliant." In addition, time to FR was assessed with predefined and previously described criteria [4, 5] (Table 2).

Study population

Liver units with a declared interest to participate in a random controlled trial (RCT) on laparoscopic liver

Table 1 ERAS core protocol elements

Preoperative
Preoperative counseling
Minimal preoperative fasting (solid food up to 6 h + clear fluids up to 2 h) + carbohydrate loading
No anxiolytic premedication
Perioperative
Thoracic epidural analgesia
Prevention of hypothermia
CVP monitoring (CVP <5 mmHg)
No routine drainage of the peritoneal cavity
No standard nasogastric drainage
Start intake of water and free fluids
Early mobilization
Postoperative nausea and vomiting (PONV) prophylaxis
Antithrombotic prophylaxis
Antibiotic prophylaxis
Postoperative days 1–3
Daily review of discharge criteria
Ileus prevention (MgO/Macrogol/Lactulose)
Free fluids/normal diet POD 1
Intravenous fluids discontinued POD 1
Oral analgesia POD 1
Normal diet POD 2
Removal of urinary catheter POD 2
Stop epidural/intravenous analgesia POD 3
Full mobilization POD 3

Table 2 Functional recovery criteria

1. Pain control with oral analgesia only
2. No intra-venous fluid support
3. Full mobilization to preoperative level
4. Eating of solid food
5. Normal serum bilirubin or returning toward normal ranges

resection in an ERAS setting [20] were invited by email to participate in this retrospective study. A total of 11 European high-volume centers (>25 cases/year) [21] participated (see list below). The last 15 consecutive patients who underwent liver surgery in each hospital were selected and reviewed (open–close procedures and biliodigestive/vascular anastomoses were excluded). Included patients were all admitted and operated on between 2010 and 2012. All patients received perioperative care according to local protocols.

ERAS experience

Three of the 11 centers indicated that they had formally implemented ERAS protocol for liver surgery. The implementation of ERAS principles in these three centers was achieved by multidisciplinary involvement, including a liver surgeon, an anesthetist, recovery ward nursing staff, and a researcher. In addition, all Dutch centers in this study had already gained experience with the ERAS program for colonic surgery as most of them participated in a nationwide structured implementation plan [22, 23]. The other hospitals were aware of the ERAS programs for liver and colonic surgery, but a structured implementation and evaluation had not yet been performed. Centers that had implemented the ERAS liver surgery program used the FR criteria (Table 2) to assess readiness for discharge. In the other centers the operating surgeon or physician on call was responsible for discharge and no strict criteria were applied.

Data and statistics

Data were anonymously collected in an Oracle 10 database (Oracle Corp., Redwood Shores, CA, USA) with OpenClinica® trial software for online data capture and management (Ikaza Research, Cambridge, MA, USA) and analyzed using SPSS ver. 19 (SPSS Inc., Chicago, IL, USA). Basic analyses were performed using descriptive statistics. To describe the compliance in the complete cohort based on results of individual centers, a random-effect logistic regression analysis was used. This adjusts for the heterogeneity of compliance among centers. The constant in the logistic regression model was transformed to an overall cohort compliance, except for three items that did not fit into the model (weighted median was used in these cases). Comparison between groups was performed using the Mann–Whitney U and Wilcoxon signed-ranks tests as appropriate. All statistical tests were two-sided, and $P < 0.05$ was considered statistically significant.

Results

Patient and surgical characteristics

A total of 165 patients were included in this study. Baseline patient characteristics are given in Table 3. Surgical details with regard to type of incision and resection are given in Table 4. Overall morbidity and the distribution of postoperative surgical complications according to the Clavien–Dindo grading system can be found in Table 5.

Primary end points

Overall compliance with the ERAS core elements varied among the assessed centers (Fig. 1). None of the participating hospitals were shown to be "fully" compliant with

Table 3 Baseline characteristics of patients ($N = 165$)

Median age (range) (years)	62 (19–89)
Male gender	83 (50)
ASA grade	
I	21 (13)
II	111 (67)
III	32 (19)
Missing	1 (1)
Malignancy	150 (91)

Values in parentheses are percentages, unless indicated otherwise

ASA American Society of Anesthesiologists

Table 4 Surgical characteristics of patients ($N = 165$)

Incision	
Laparoscopic	22 (13)
Kocher's/J-shaped	81 (49)
Bilateral subcostal	19 (12)
Mercedes	12 (7)
Median	13 (8)
Other[a]	11 (7)
NA	7 (4)
Liver resection	
Minor (<3 segments or non-anatomical)	93 (56)
Major (≥3 segments)	45 (27)
Simultaneous non-hepatic	27 (16)
Type	
Wedge resection/segmentectomy	46 (28)
Bisegmentectomy	23 (14)
Right hepatectomy	24 (15)
Left hepatectomy	2 (1)
Deroofing/enucleation	1 (1)
Extended right hepatectomy	4 (2)
Extended left hepatectomy	2 (1)
Multiple wedge resections/segmentectomies	35 (21)
Major (≥3 segments)	10 (6)
Other[b]	28 (17)
Major (≥3 segments)	3 (2)

Values in parentheses are percentages

NA not available

[a] Thoracoabdominal and xiphopubic incisions

[b] Hepatic resections combined with RFA or nonhepatic procedures

the complete set of core ERAS elements. Centers provided a median number of 9 (range = 7–12) of pre-, peri-, and postoperative care items according to the ERAS protocol. Five hospitals were partially compliant (11 or more items) and the remaining six hospitals were poorly compliant to the core elements. A summary of the overall compliance per ERAS element across all units ($N = 165$ patients) is given in Tables 6 and 7.

Table 5 Morbidity ($N = 165$)

Overall morbidity	47 (28)
Clavien–Dindo	
Grade I	8 (5)
Grade II	26 (16)
Grade IIIa	6 (4)
Grade IIIb	2 (1)
Grade IVa	5 (3)
Grade IVb	–
Grade V (death)	–
Readmissions	3 (2)

Values in parentheses are percentages

Preoperative

Median compliance of the centers with preoperative core items was partial (66 %, 2 of 3 elements, range = 1–3). All centers provided preoperative counselling, predominantly on procedural issues and complications. Three centers provided extensive counselling, with attention to postoperative elements such as early oral feeding and mobilization, FR, and discharge criteria. No record of preoperative counselling could be found for 2 % of the patients. For 94 % (60–100) of the patients, preoperative fasting was reduced to a minimum. Anxiolytic premedication was not given to 43 % (13–100) of the patients.

Perioperative

Median compliance with perioperative core items was partial (50 %, 5 of 10 elements, range = 4–7). Ninety-six percent (87–100) of the patients received active prevention of hypothermia and 81 % (0–100) received thoracic epidural anesthesia. In 13 % (0–13), the procedure was laparoscopically performed, and in 49 % (26–100), a right subcostal incision was used. In 47 % (0–100) of the patients, the central venous pressure (CVP) was closely monitored and kept below 5 mmHg during parenchymal transection. In 53 % (0–100) of the patients, nasogastric tubes (NGT) were removed immediately after the operation, and in 41 % (7–100), abdominal drains were not used. In contrast to antithrombotic and antibiotic prophylaxes, prophylaxis for postoperative nausea and vomiting (PONV) was frequently provided, but not as per routine in all patients.

Postoperative

Median compliance of the centers with postoperative core items was poor (22 %, 2 of 9 elements, range = 0–6).

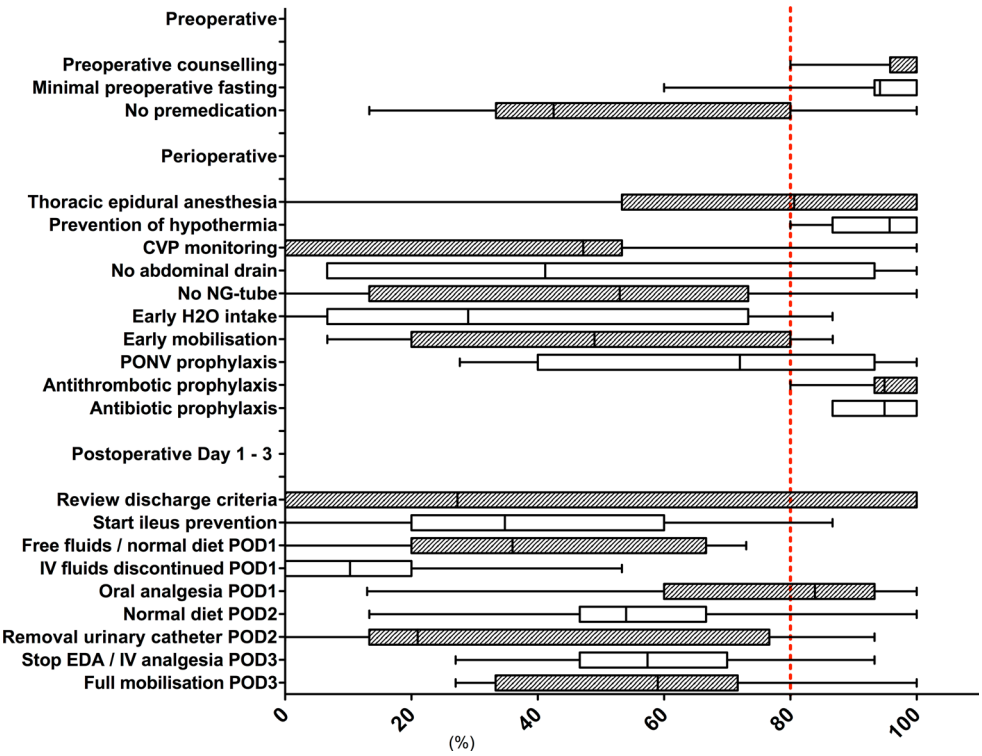

Fig. 1 Box plots of overall compliance per ERAS core elements of 11 participating centers. Box plots resemble the 25–75 % confidence intervals. *Black vertical line within a box* is the median value. The *vertical dotted line* represents the 80 % compliance cut-off value

Early oral fluid intake, directly after surgery, was commenced in only 42 % (7–87) of the patients on POD 0, and only 36 % (0–73) tolerated free fluids or a normal diet on POD 1 (independent of the extent of liver surgery). After surgery patient-controlled intravenous (PCIA) or epidural analgesia (PCEA) was started in 83 % (0–93) of the patients as the standard of care. Oral analgesia was provided to 90 % (13–93) of patients, but in 14 % oral pain medication was not started until POD 2. Mobilization was achieved in only 50 % (13–93) of the patients on POD 1. In 56 % (0–73) of the patients, IV support was discontinued on POD 3. Urinary catheters were removed on POD 3 in 52 % (0–93), and they were usually not removed until the day of or the day after thoracic epidural anesthesia was discontinued. Signs of return of bowel function (flatulence and/or stool) were seen in 71 % (13–93) of patients on POD 3.

Secondary end points

Data on the day of discharge and the time to FR are depicted in Fig. 2. The median length of stay (LOS) after surgery was 7 (range = 1–27) days and 31, 49, and 64 % of all patients were discharged on POD 5, 6, and 7, respectively. Using the FR criteria, a majority of the patients could be considered functionally recovered on median POD 5 (1–24). This difference between discharge and time to FR was statistically significant ($P < 0.001$). Eighty-one percent ($N = 133$) of the patients were not discharged on the day that FR criteria were fulfilled. In 29 % of patients, complications were responsible for prolonged hospitalization (Table 5). Although time to FR and LOS were in favor of the centers that were partially compliant with the ERAS program, differences did not reach statistical significance (Figs. 3, 4).

Discussion

This study evaluated the current perioperative care in 11 high-volume European liver surgery centers by assessing compliance with an ERAS program. Perioperative care varied considerably among the centers. All of the participating institutions had already adopted a median of 9 (range = 7–12) elements of the ERAS care program as part of modern surgical practice. None of the centers had implemented the complete set of core elements. Interestingly, pre- and perioperative elements had the best implementation, but the centers were especially poor at complying with ERAS elements in the postoperative phase. In addition, a significant discrepancy between the patient's recovery and actual discharge was observed.

Every center consistently provided preoperative counseling, limited the fasting period, actively prevented hypothermia during surgery, and systematically administered antithrombotic and antibiotic prophylaxes. Also,

Table 6 Compliance with ERAS elements

	N/total *N* (%)	Overall median compliance (range)
Preoperative		
Preoperative counselling	162/165 (98)	96 (80–100)
Assessment of discharge arrangements	120/165 (73)	73 (0–100)[a]
Assessment of mobility	122/164 (74)	74 (0–100)[a]
Daily review of discharge criteria	45/165 (27)	27 (0–100)[a]
Normal oral diet up to 6 h + clear fluid intake up to 2 h	155/165 (94)	94 (60–100)
No anxiolytic premedication	91/162 (56)	43 (13–100)
Perioperative		
Thoracic epidural anesthesia (EDA)	119/165 (72)	81 (0–100)
Prevention of hypothermia	157/160 (98)	96 (87–100)
Laparoscopy/right subcostal incision	102/159 (64)	65 (13–87)
CVP monitoring (CVP < 5 mmHg)	47/102 (46)	47 (0–100)
No postoperative nasogastric tube	72/161 (45)	53 (0–100)
No routine use of abdominal drain	76/165 (46)	41 (7–100)
Postoperative day (POD) 0		
PONV prophylaxis	110/164 (67)	72 (27–100)
Antithrombotic prophylaxis	157/164 (96)	95 (80–100)
Antibiotic prophylaxis	155/162 (96)	95 (87–100)
Oral fluid intake	100/162 (62)	42 (7–87)
Mobilization at all	13/150 (9)	6 (7–87)
Start oral analgesia	86/163 (51)	51 (7–100)
Use of patient-controlled analgesia (EDA or IV)	132/165 (80)	83 (0–93)
POD 1		
Nasogastric tube removed	107/160 (67)	66 (0–100)
Tolerance of free fluids/normal diet	63/165 (38)	36 (0–73)
Mobilization at all/out of bed	82/160 (51)	50 (7–87)
No intravenous fluids	17/165 (10)	10 (0–53)
Oral analgesia	129/165 (78)	84 (13–100)
Use of patient-controlled analgesia (EDA or IV)	114/165 (69)	75 (0–93)
CAD removal	14/161 (9)	5 (0–60)
Flatulence and/or stool	15/148 (10)	10 (0–20)
POD 2		
Normal diet	101/165 (61)	54 (13–100)
Mobilization out of bed	118/159 (74)	76 (13–93)
No intravenous fluids	34/165 (21)	19 (0–67)
Oral analgesia	135/165 (82)	86 (13–93)
Use of patient-controlled analgesia (EDA or IV)	91/165 (55)	54 (0–87)
CAD removal	41/159 (26)	21 (0–93)
Flatulence and/or stool	59/145 (41)	41 (0–67)
POD 3		
Normal diet	120/165 (73)	73 (13–93)
Full mobilization	81/151 (57)	59 (27–100)
No intravenous fluids	76/165 (46)	56 (0–73)
Oral analgesia	139/165 (84)	90 (13–93)
Use of patient-controlled analgesia (EDA or IV)	46/165 (28)	25 (0–87)
CAD removal	85/157 (54)	52 (0–93)
Flatulence and/or stool	108/154 (70)	71 (13–93)
Use of cathartics and/or laxatives	61/165 (37)	35 (0–87)

Overall median compliance represents all assessed centers ($N = 11$)

CVP central venous pressure, *PONV* postoperative nausea and vomiting, *IV* intravenous, *CAD* catheter à démeure

[a] Weighted median

PONV prophylaxis, the use of epidural anesthesia, and patient-controlled analgesia already had a prominent place. In contrast to the aforementioned care elements, other ERAS components were absent or suboptimally implemented. The partial or poor compliance and wide variation among the centers mirror this.

During the preoperative phase, anxiolytic medication was commonly used. Two striking perioperative observations were the widespread use of abdominal drains and NGT. In addition, the CVP during parenchymal transection was poorly documented. In the postoperative phase, the resumption of oral intake, removal of the urinary catheter, use of laxatives, and mobilization were only poorly implemented.

Based upon previous studies, it is known that preoperative counseling on the role and expectations of the patient in the recovery period could further optimize postoperative recovery and satisfaction [24, 25]. Also, the use of anxiolytic premedication could negatively influence gastrointestinal motility and, although it is safe to use short-acting benzodiazepines in day surgery [26], their efficacy for major surgery remains unclear.

Important accumulated evidence for the perioperative phase has shown that the necessity of abdominal drains can be questioned after uncomplicated liver resection [27]. Equally, it is well known that it is safe to remove NGTs directly after abdominal surgery [28]. The use of an NGT is even associated with an increased risk of developing postoperative pulmonary complications [28, 29].

There is an ongoing discussion concerning central venous pressure monitoring (CVP <5–10 mmHg). Low CVP can be utilized to minimize back bleeding during parenchymal transection and to avoid excessive administration of IV fluids [30–32]. However, it could be argued

Table 7 Compliance with ERAS core elements per center

	Centers										
	A	B	C	D	E	F	G	H	I	J	K
Preoperative											
Preoperative counselling (%)	100	100	100	100	100	100	100	80	93	100	100
Minimal preoperative fasting (%)	60	100	100	100	100	100	100	80	93	100	100
No anxiolytic premedication (%)	13	67	80	40	40	27	80	100	87	20	53
Perioperative											
Thoracic epidural analgesia (%)	100	93	100	80	87	93	100	53	7	0	80
Prevention of hypothermia (%)	87	93	93	100	80	100	100	100	87	100	100
CVP monitoring (%)	13	33	13	53	7	0	0	100	20	73	0
No routine drainage of the peritoneal cavity (%)	67	53	100	93	100	27	53	7	7	7	87
No standard nasogastric drainage (%)	27	40	13	67	73	7	53	0	13	87	100
Start intake of water/free fluids (%)	7	40	80	0	47	13	67	0	0	80	87
Early mobilization (%)	7	47	33	53	20	13	80	87	40	87	73
PONV prophylaxis (%)	80	27	93	73	93	47	100	40	93	33	60
Antithrombotic prophylaxis (%)	93	80	93	93	100	100	100	100	100	93	100
Antibiotic prophylaxis (%)	100	100	87	93	100	87	93	100	93	100	87
Postoperative days 1–3											
Daily review of discharge criteria (%)	0	0	0	100	0	0	100	0	0	0	100
Ileus prevention (%)	27	13	40	87	27	60	20	27	0	80	27
Free fluids/normal diet POD 1 (%)	20	33	20	73	47	33	67	0	7	53	67
Intravenous fluids discontinued POD 1 (%)	0	0	0	0	0	0	53	0	33	20	7
Oral analgesia POD 1 (%)	100	87	93	100	60	93	93	13	73	53	93
Normal diet POD 2 (%)	40	67	47	100	53	67	40	13	73	100	73
Removal of urinary catheter POD 2 (%)	0	47	7	13	13	7	0	27	40	93	33
Stop epidural/intravenous analgesia POD 3 (%)	27	80	53	73	53	33	60	60	93	60	40
Full mobilization POD 3 (%)	27	73	60	80	40	27	33	67	100	33	33

Total $N = 165$, with 15 patients per center

CVP central venous pressure, *PONV* postoperative nausea and vomiting, *POD* postoperative day

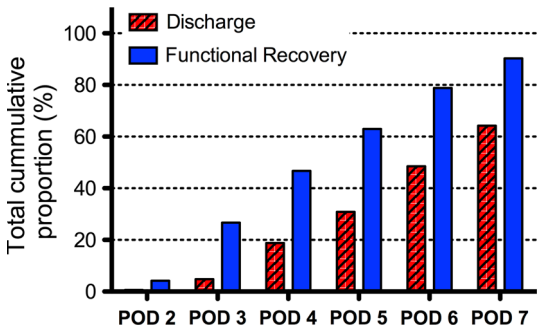

Fig. 2 Discharge versus functional recovery, $P < 0.001$. Cumulative proportion of all patients ($N = 165$) who were discharged on POD 2–7 and who were functionally recovered (FR). *POD* postoperative day

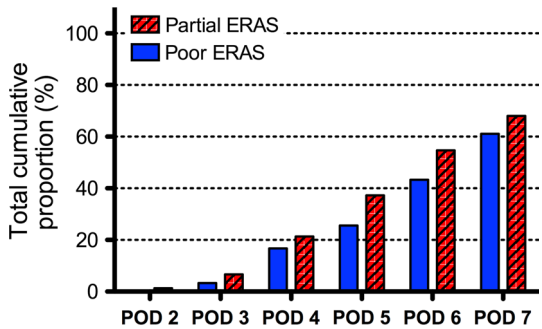

Fig. 3 Discharge in partial ERAS centers ($N = 5$) versus poor ERAS centers ($N = 6$), $P = 0.166$. Cumulative proportion of patients who were discharged on POD 2–7

that CVP monitoring is not strictly necessary in minor hepatectomies, which represent a majority in the present study.

Lastly, patient-controlled analgesia may help to reduce opioid use and its associated side effects [33]. However, there is debate concerning the role of epidural catheters (EDA). Although frequently used in the participating centers, they are no longer used in an increasing number of other hospitals that perform liver surgery. Not only can the technique be contraindicated, e.g., because of the presence

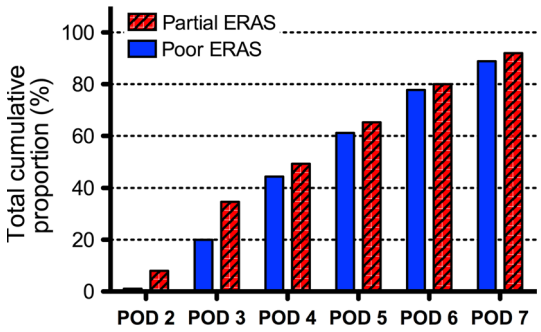

Fig. 4 Functional recovery in partial ERAS centers ($N = 5$) versus poor ERAS centers ($N = 6$), $P = 0.149$. Cumulative proportion of patients who were functionally recovered on POD 2–7

of coagulopathy, it can also cause potentially serious complications such as epidural hematoma, abscess, or paralysis [34]. The epidural catheterization is more time-consuming than intravenous analgesia and fails to provide adequate analgesia in >20 % of the patients [35].

It may be felt that ERAS principles are not uniformly applicable to all patients and other factors (e.g., age, comorbidity, indication for surgery, and extent of liver resection) could play a role. There are good alternatives to core elements that would not deter from the ERAS principles. Postoperative pain has traditionally been managed by intravenous or epidural analgesia. It can be argued whether the inclusion of thoracic epidural analgesia as a core element reflects current clinical practice. The use of wound catheters with a local anesthetic [36–38] or the use of intrathecal morphine [39] has been shown to be safe and effective also in an ERAS setting for liver surgery [40, 41]. Furthermore, alternatives to reduce CVP or monitor it could serve as a substitute and may be sufficient [42, 43].

In the postoperative phase, the still abundant use of NGTs could explain why early intake of water on POD 0 was achieved in only less than one third of the patients and why only half of the patients tolerated a normal diet on POD 2. A quick return to a normal diet has been shown to be safe for both major upper abdominal and colorectal surgeries [44, 45]. In addition, to promote the return of normal bowel function or prevent a postoperative ileus, standard use of laxatives has been shown to be effective [4, 5]. Lastly, few patients mobilized out of bed before POD 2. The use of drains, lack of daily mobilization goals, and relatively late removal of catheters can explain this observation.

A secondary outcome was the length of hospital stay versus the time to FR. It is generally agreed that it is medically justified to discharge patients when criteria for full FR are met [4, 5, 20]. In keeping with literature data [4, 19], a discrepancy was found between discharge and time to FR. A majority of patients (63 %) principally were functionally recovered on median POD 5 (range = 1–24), while only 31 % were discharged at that time. Factors influencing this delay could have been poor organization of discharge logistics, cultural differences, and deviant patient expectations. Unfortunately, it was not possible to assess all five FR criteria because serum bilirubin values were inconsistently available. Bilirubin values were therefore assumed normal since the majority of the liver resections in this study were minor procedures.

The retrospective assessment of the data, the selection of participating centers, and their varying experience with ERAS principles may have biased our results. However, this design was deliberately chosen so as to not influence the behavior of medical and nursing staff in perioperative care during a full prospective assessment. Both large and small hepatic centers were allowed to participate and this could also have influenced our results. However, the large number of minor resections in this study and the participation of several high-volume European centers with varying experience with ERAS protocols do provide a reflection of daily practice in liver surgery and therefore increase external validity.

Based on this study several recommendations can be made that could eventually lead to further optimization of care and potentially improve postoperative outcomes. Change of current practice and implementation of an enhanced-recovery care pathway are desirable but will require multidisciplinary efforts [19, 46]. Although counseling is already part of preoperative care in that information on the procedure and possible complications is provided, there should be more emphasis on the recovery period with respect to pain control, early mobilization, resumption of intake, and time of discharge. Furthermore, administration of preoperative anxiolytic medication should not be the standard. Recommendations for the perioperative phase include the selective monitoring of the CVP and abandoning the standard use of abdominal drains and the dogmatic use of NGT. For patients undergoing liver surgery, the use of NGTs is not needed at all and seems very conservative. In combination with adequate PONV prophylaxis, a safe and quick return to a normal diet may be facilitated. In addition, laxatives can be provided in a standard manner, urinary catheters should be removed earlier, and daily mobilization goals should be determined. Lastly, predefined discharge criteria should be checked daily to minimize a delay in discharge after FR.

The findings of this study are clinically relevant to liver surgeons as they aim for a universally accepted and standardized perioperative care program. The findings may help to provide the standardization needed for comparability in clinical audits and trials. Future research should clarify the role of the individual components in ERAS programs and investigate to what extent an element contributes to the improvement of outcomes. Several recent

studies [8–10] have already demonstrated the additional value of ERAS programs with predefined discharge criteria. In addition, safe and effective alternatives or new elements should be embraced.

Conclusion

Perioperative care among centers that perform liver resections varied substantially and elements of enhanced-recovery programs had already been implemented as part of daily surgical practice. Other elements can be further optimized based on ERAS principles. This may standardize care and improve recovery after liver surgery.

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Conflict of interest The authors declare no conflicts of interest.

Appendix

ERAS Liver Protocol Baseline – Checklist:

Hospital:	**Ptn.nr:**	**Date of birth:**	**ASA:**
Complications:			
Readmission (<30 days): yes /no			

Preoperative:		**Comments:**
Date:		
Yes	**No**	
☐	☐	Preoperative counselling (if yes, specify)
☐	☐	Assessment of discharge arrangements
☐	☐	Preoperative mobility assessment

Day of admission:		**Comments:**
Date:		
Yes	**No**	
☐	☐	Pre-anaesthetic medication (if yes, specify)
☐	☐	Standard preoperative laboratory tests (specify)

Day of surgery (peroperative):			Comments:
Date:			
Yes	**No**		
☐	☐	Preoperative fasting (if yes, specify regime and hours before surgery)	
Surgeon			
Yes	**No**		**Comments:**
☐	☐	Minimal invasive incisions / laparoscopy (specify type of surgery)	**Type of incision:** **Type of surgery:**
☐	☐	CAD	
☐	☐	Use of abdominal drains	
Anaesthesiology			
Yes	**No**		**Comments:**
☐	☐	Antibiotic prophylaxis (before incision)	
☐	☐	Arterial line	
☐	☐	Intravenous infusion	
☐	☐	CVP catheter	
☐	☐	Hemodynamic monitoring	
☐	☐	Anaesthesia (specify type)	
☐	☐	Epidural (if yes, location)	
☐	☐	Upper and lower body air-warming device > 36 °C	
☐	☐	Nasogastric decompression tube	
☐	☐	CVP <5 mmHg perioperative	
☐	☐	PONV prophylaxis (specify)	
☐	☐	Antithrombotic prophylaxis (LMWH)	

Yes	No		Comments:
☐	☐	Arterial line removed	
☐	☐	CVP catheter removed	
☐	☐	Nasogastric decompression tube removed (if used)	

Recovery / Ward (POD 0):			Comments:
Date:			
Yes	No		
☐	☐	Use of analgesia (PCA / Epidural / PCEA)	
☐	☐	Daily pain assessment	
☐	☐	CAD	
☐	☐	Patient journal	
☐	☐	Oral analgesics (if yes, specify)	
☐	☐	IV fluids	
☐	☐	Oral intake of water / carbohydrate drinks	
☐	☐	Mobilisation (if yes, specify)	
☐	☐	(Semi-) solid food intake in the evening	
☐	☐	Laxatives (if yes, specify type, dosage and duration)	
☐	☐	Stools/flatulence	

POD 1 (ward):			Comments:
Date:			
Yes	No		
☐	☐	Use of analgesia (PCA / Epidural / PCEA)	
☐	☐	Daily pain assessment	
☐	☐	CAD	
☐	☐	Oral analgesics	
☐	☐	IV fluids	
☐	☐	Normal diet / patient drinks 1.5 L + solid food intake	
☐	☐	Mobilisation (if yes, specify)	
☐	☐	Laxatives	
☐	☐	Stools/flatulence	
☐	☐	Standard postoperative laboratory tests (specify)	
☐	☐	Ready for discharge (if yes, specify criteria)	

POD 2:			Comments:
Date:			
Yes	No		
☐	☐	Use of analgesia (PCA / Epidural / PCEA)	
☐	☐	Daily pain assessment	
☐	☐	CAD	
☐	☐	Oral analgesics	
☐	☐	IV fluids	
☐	☐	Normal diet	
☐	☐	Mobilisation (if yes, specify)	
☐	☐	Laxatives	
☐	☐	Stools/flatulence	
☐	☐	Ready for discharge (if yes, specify criteria)	

POD 3:			Comments:
Date:			
Yes	No		
☐	☐	Use of analgesia (PCA / Epidural / PCEA)	
☐	☐	Daily pain assessment	
☐	☐	CAD	
☐	☐	Oral analgesics	
☐	☐	IV fluids	
☐	☐	Normal diet	
☐	☐	Mobilisation (if yes, specify)	
☐	☐	Laxatives	
☐	☐	Stools/flatulence	
☐	☐	Standard postoperative laboratory tests (specify)	
☐	☐	Ready for discharge (if yes, specify criteria)	
☐	☐	Discharge arrangements made	

POD 4:			Comments:
Date:			
Yes	No		
☐	☐	Discharged	
☐	☐	If not discharged: care continued as on **POD3**?	

POD 5:			Comments:
Date:			
Yes	No		
☐	☐	Discharged	
☐	☐	If not discharged: care continued as on **POD4**?	

POD 6:			Comments
Date:			
Yes	No		
☐	☐	Discharged	
☐	☐	If not discharged: care continued as on **POD5**?	

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