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ENHANCED RECOVERY AFTER SURGERY (ERAS) PROTOCOL (PREOPERATIVE AND INTRAOPERATIVE PARAMETERS) IN DONOR HEPATECTOMY: A PROSPECTIVE OBSERVATIONAL STUDY

Anaesthesiology

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ABSTRACT

Background: Enhanced Recovery After Surgery (ERAS) protocols have revolutionized perioperative care by optimizing patient outcomes, reducing complications and shortening hospital stays. This study evaluates the impact of perioperative anesthetic management on early recovery after donor hepatectomy within an ERAS framework. **Methodology:** A prospective observational study was conducted from April 2023 to March 2025 at Mahatma Gandhi Medical College & Hospital, Jaipur. 74 patients aged 18-65 years (ASA I-III) undergoing elective hepatectomy were included. The study evaluated ERAS implementation feasibility, hospital stay duration, early recovery parameters, patient satisfaction, complications and readmission rates. **Results:** The mean age was 33.23 ± 9.64 years with 63.5% females and 36.5% males. Most patients (87.8%) were ASA-I. Right hepatectomy was performed in 93.2% of cases. The mean surgical duration was 487.27±86.91 minutes with average blood loss of 559.46 ± 229.51 ml. Normal recovery (<7 days) was achieved in 64.9% of patients. Intraoperative complications occurred in 12.2% and postoperative complications in 44.6% of patients. No 30-day readmissions occurred. **Conclusion:** ERAS-guided preoperative and intraoperative anesthetic management significantly supports early recovery after hepatic resections. The structured approach with multimodal analgesia, optimized preoperative and intraoperative monitoring and duration of surgery resulted in favorable outcomes with 64.9% of patients achieving normal recovery within seven days.

KEYWORDS

Enhanced Recovery After Surgery, ERAS, donor hepatectomy, perioperative anesthesia, early recovery, multimodal analgesia.

INTRODUCTION

Enhanced Recovery after Surgery (ERAS) is a multimodal, patient-centered pathway aimed at reducing surgical stress, enhancing healing and promoting faster recovery through strategies such as preoperative education, optimized fluid management, multimodal analgesia and early mobilization [1,2]. The concept was pioneered in the 1990s by Henrik Kehlet, who demonstrated improved recovery in colorectal surgery, establishing the foundation for ERAS across multiple surgical specialties [3]. Today, ERAS is a standardized, evidence-based approach applied widely in colorectal, urological, orthopaedic and hepatobiliary surgeries, emphasizing nutritional optimization, opioid-sparing analgesia and early postoperative care [4,5].

Anaesthesiologists are central to ERAS, contributing to preoperative optimization, opioid-sparing anaesthesia, multimodal pain control and intraoperative fluid and hemodynamic management [6]. Hepatectomy, however, poses challenges due to the liver's complex vascular anatomy and risks of bleeding, hemodynamic instability and impaired drug metabolism, requiring vigilant monitoring and tailored anaesthetic strategies [7–9]. Donor hepatectomy differs from disease-related resections, as it involves healthy individuals where donor safety and rapid recovery are paramount. The procedure requires careful selection, preservation of liver function and psychological support for donors [10].

Integrating ERAS principles into donor hepatectomy enhances outcomes by reducing perioperative stress, improving hemodynamic stability, facilitating early mobilization and minimizing opioid-related side effects, thereby promoting faster recovery and liver regeneration [11]. Despite challenges such as fluid shifts, bleeding and risks of systemic complications, ERAS mitigates these through optimized perioperative care. Successful implementation depends on a multidisciplinary team like surgeons, anaesthesiologists, nurses, physiotherapists and dietitians, who must work cohesively with expertise in their respective roles to ensure effective execution of ERAS pathways [12,13]. This study aims to evaluate the clinical impact of preoperative and intraoperative anesthetic management within an ERAS framework for hepatic resections, providing valuable insights into how optimized anesthetic strategies can enhance surgical outcomes and reduce morbidity in hepatic surgery.

METHODOLOGY

This prospective observational study was conducted in the Department of Anesthesiology, Critical Care and Pain Management at Mahatma Gandhi Medical College & Hospital, Jaipur, Rajasthan, over a 24-month period from April 2023 to March 2025. The study protocol received approval from the Institutional Ethics Committee and written informed consent was obtained from all participants prior to enrollment. The study included all patients aged between 18-65 years of both genders with American Society of Anesthesiologists (ASA) physical status classification I, II and III who were scheduled for elective hepatectomy during the study period. Patients were excluded if they had a body mass index above 30 kg/m², uncontrolled comorbidities such as diabetes mellitus, hypothyroidism, or hypertension, history of cerebrovascular disease or known or newly diagnosed coagulopathy.

Preoperative Assessment And Preparation:

All patients underwent comprehensive preoperative evaluation using a pre-structured, pre-tested proforma. This included detailed medical history, physical examination encompassing vital signs assessment, anthropometric measurements and systematic examination of cardiovascular, respiratory and central nervous systems. Airway assessment was performed using standard protocols. Laboratory investigations included complete blood count, blood grouping and Rh typing, fasting blood glucose, renal function tests (blood urea and serum creatinine), liver function tests, coagulation profile (bleeding time, clotting time, prothrombin time and INR), serum electrolytes, chest X-ray and electrocardiogram. Additional assessments included pulmonary function tests with FEV1 and FEV1/FVC measurements and Child-Pugh scoring for liver function assessment.

Outcome Measures:

Recovery profiles were categorized as normal (<7 days) or delayed (>7 days) based on hospital discharge criteria.

Statistical Analysis:

Data were entered and cleaned using Microsoft Excel and analyzed

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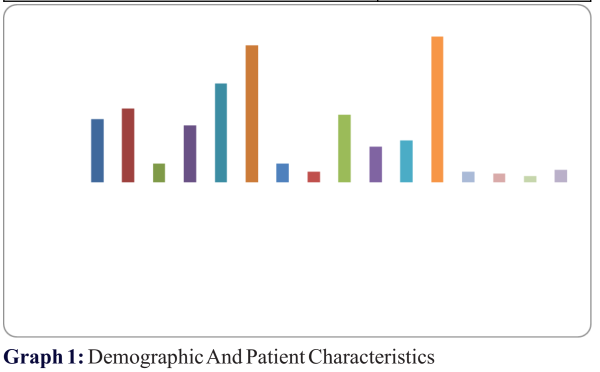
using SPSS version 25. Quantitative variables were expressed as mean ± standard deviation or median ± interquartile range as appropriate. Qualitative data were presented as percentages and proportions. Normality testing was performed using Kolmogorov-Smirnov and Shapiro-Wilk tests. Correlation analysis was conducted for various pre-, intra-operative variables. ANOVA testing was used to assess variable dependencies on recovery profiles. Chi-square analysis evaluated associations between categorical variables and recovery outcomes. Statistical significance was set at $p < 0.05$.

RESULTS

The study enrolled 74 patients meeting the inclusion criteria. The demographic and baseline characteristics are presented in Table 1. The mean age of participants was 33.23 ± 9.64 years with the majority (47.3%) falling within the 31-45 years age group, followed by 40.5% in the 18-30 years group. Female patients constituted 63.5% of the study population, while males represented 36.5%. The vast majority of patients (87.8%) were classified as ASA I with only 12.2% classified as ASA II. Mean height and weight were 161.36±8.12cm and 60.07±9.34kg, respectively. Body mass index distribution showed 43.2% of patients with normal BMI, 27% obese, 23% overweight and 6.8% underweight.

Table 1: Demographic And Patient Characteristics

Parameter	Value
Age (years)	
Mean ± SD	33.23 ± 9.64
18-30 years, n (%)	30 (40.5)
31-45 years, n (%)	35 (47.3)
46-60 years, n (%)	9 (12.2)
Gender, n (%)	
Male	27 (36.5)
Female	47 (63.5)
ASA Classification, n (%)	
ASA I	65 (87.8)
ASA II	9 (12.2)
Anthropometry	
Height (cm), Mean ± SD	161.36 ± 8.12
Weight (kg), Mean ± SD	60.07 ± 9.34
BMI Distribution, n (%)	
Underweight (<18.5)	5 (6.8)
Normal (18.5-22.9)	32 (43.2)
Overweight (23-24.9)	17 (23.0)
Obese (≥25)	20 (27.0)
Surgery Type, n (%)	
Right hepatectomy	69 (93.2)
Left hepatectomy	5 (6.8)
Comorbidities, n (%)	
Hypothyroidism	4 (5.4)
Hypertension	3 (4.1)
Others	6 (8.1)



Graph 1: Demographic And Patient Characteristics

Preoperative Assessment And Preparation

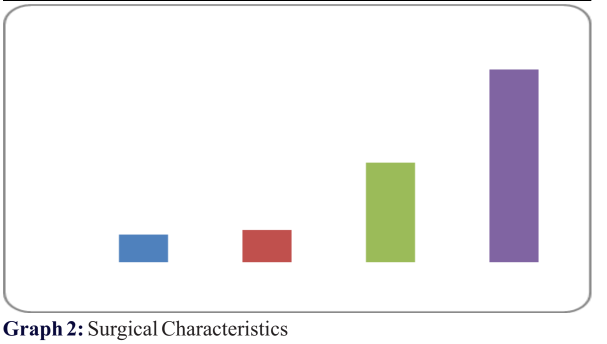
All patients underwent comprehensive preoperative counseling (100%) and received antibiotic prophylaxis. Bowel preparation was performed in 47.3% of patients. VTE prophylaxis was universal with 64.9% receiving heparin, 59.5% DVT pumps and 4.1% enoxaparin. Mean pulmonary function parameters showed FEV1/FVC of 99.43 ± 7.51% and FEV1 of 78.99 ± 10.74%. The average preoperative fasting duration was 5.84 ± 2.37 hours. Preoperative laboratory parameters demonstrated mean hemoglobin levels of 13.19 ± 1.73 g/dl, total leukocyte count of 7541.89 ± 1820.91 per mm^3 and platelet count of 2.60 ± 0.81 lakhs per mm^3. Liver function tests showed mean total bilirubin of 0.70 ± 0.35 mg/dl, SGOT of 58.77 ± 17.10 U/L and SGPT of 45.49 ± 7.11 U/L. Coagulation parameters included prothrombin time of 11.90 ± 0.87 seconds and INR of 1.07 ± 0.10. Mean Child-Pugh score was 5.05 ± 0.23, indicating well-preserved liver function.

Intraoperative Management and Outcomes

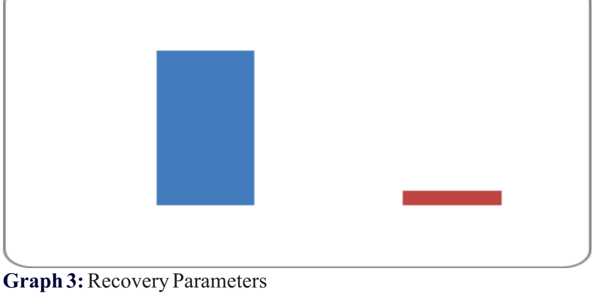
Intraoperative care followed standardized ERAS protocols with consistent monitoring and intervention strategies. Chlorhexidine (2%) skin preparation was used in 70.3% of cases. General anesthesia was administered using sevoflurane in 73% of patients and isoflurane in 27%. Fentanyl was co-administered in 64.9% of cases. Ryles tube insertion was performed in 95.9% of patients. Epidural anesthesia was successfully established in 98.6% of patients with catheter placement most commonly at T9-T10 (35.1%) and T8-T9 (28.3%) interspaces. All patients received multimodal analgesia including paracetamol, magnesium sulfate and dexamethasone. Antioxidant therapy, primarily N-acetylcysteine, was administered to 93.2% of patients. Intraoperative monitoring revealed successful maintenance of physiological parameters in the majority of patients. Temperature control was easily maintained in 54.1% and maintained in 45.9% of patients. End-tidal CO_2 was easily maintained in 43.2% and maintained in 52.7% of patients. Mean arterial pressure control was achieved easily in 44.6%, maintained in 35.1% and was challenging in 20.3% of cases. Central venous pressure was easily maintained in 59.5% and maintained in 28.3% of patients. Glucose management was successful with easy maintenance in 63.5% and adequate control in 36.5% of cases.

Table 2: Intraoperative Management And Outcomes

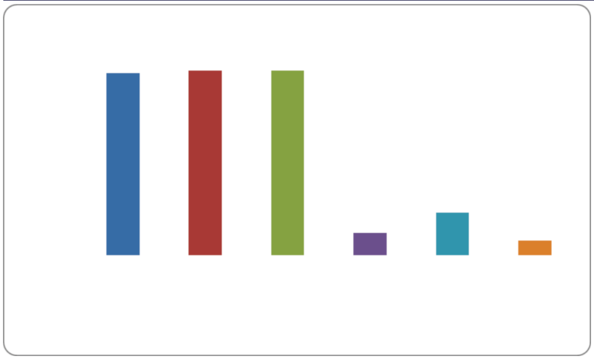
Parameter	Mean ± SD
Surgical Characteristics	
Duration of surgery (minutes)	487.27 ± 86.91
Blood loss (ml)	559.46 ± 229.51
Urine output (ml)	1753.11 ± 578.25
Fluid management intake (ml)	3383.11 ± 638.40
Recovery Parameters	
Time to modified Aldrete Score 10 (minutes)	23.93 ± 18.01
Pain score (0-10)	2.24 ± 1.50
Anesthetic Management	
Epidural procedure, n (%)	73 (98.6)
Multimodal analgesia, n (%)	74 (100)
Anti-emetics administration, n (%)	74 (100)
Complications	
Intraoperative complications, n (%)	9 (12.2)
Post-extubation complications, n (%)	17 (23.0)
Inotropic support requirement, n (%)	6 (8.1)



Graph 2: Surgical Characteristics



Graph 3: Recovery Parameters

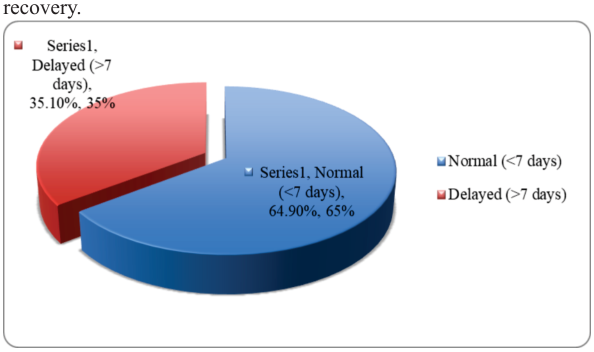


Graph 4: Anesthetic Management And Complications

Table 3: Distribution Of Patients According To Recovery Profile

Recovery Profile	Frequency (n)	Percentage (%)
Normal (<7 days)	48	64.9%
Delayed (>7 days)	26	35.1%

The overall recovery profile showed that 64.9% of patients achieved normal recovery within seven days, while 35.1% experienced delayed recovery.



Graph 5: Recovery Profile

DISCUSSION

The findings of this prospective observational study demonstrate the significant benefits of implementing Enhanced Recovery After Surgery (ERAS) protocols in donor hepatectomy with 64.9% of patients achieving normal recovery within seven days. These results align with growing evidence supporting ERAS implementation in hepatobiliary surgery and underscore the critical role of optimized perioperative anesthetic management in achieving superior patient outcomes.

In our study, most patients were females (63.5%) with a mean age of 33.23±9.64 years, predominantly between 18-45 years. By contrast, Schmelzle et al.[14] reported an older ERAS cohort with mean age of 61 years and only 42.7% females, while Dasari et al.[15] and Huang H et al.[16] similarly described older, male-predominant groups. Chong C et al.[17] also found a median age of 58 years, highlighting demographic differences that may affect recovery trajectories. ASA grading in our cohort showed 87.8% ASA I and 12.2% ASA II, in contrast to Riscanevo-Bobadilla C et al.[18], where most patients were ASA III–IV, whereas Zhou J et al.[19] reported a similar distribution to ours. Anthropometric assessment revealed mean height of 161.36 ± 8.12 cm and mean weight of 60.07 ± 9.34 kg with 43.2% normal BMI, 27% obese, 23% overweight and 6.8% underweight. Compared with Saunders JK et al.[20] (U.S. cohort) and Wang H et al. [21] (Chinese cohort), our patients had fewer overweight individuals but a higher obesity rate by local criteria. Fischer et al.[22] and O'Connell et al.[23] further emphasized the impact of higher BMI on postoperative morbidity and adverse hepatic pathology. Surgical distribution showed 93.2% undergoing right hepatectomy and 6.8% left hepatectomy, which differs markedly from Teixeira UF et al.[24] Andert A et al.[25] and Jo HS et al.[26], who reported higher proportions of left-sided resections. Comorbidities were present in only 17.6% of our cohort, most commonly hypothyroidism and hypertension. In comparison, Dasari et al.[15], Wang B et al.[27] and Ni et al. [28] reported higher overall comorbidity burdens (22–30%), mainly due to hypertension and diabetes.

In our study, the mean operative time was 487.27 ± 86.91 minutes with an average blood loss of 559.46 ± 229.51 ml, fluid intake of 3383.11 ± 638.40 ml and urine output of 1753.11 ± 578.25 ml. Recovery parameters showed a mean time of 23.93 ± 18.01 minutes to achieve a Modified Aldrete Score of 10 with mean pain scores of 2.24 ± 1.50. Compared to Monden et al.[29] (214 minutes, 214 ml blood loss, 950 ml fluids) and Cheung et al.[30] (270 ± 80 minutes), our operative times and volumes were higher, reflecting complexity of open donor hepatectomy. Zhu A et al.[31] reported intraoperative fluids of 2500 ± 600 ml, aligning with our findings, while Dieu A et al.[32] observed slightly higher VAS scores than in our cohort. Epidural analgesia was used in 98.6% of patients, consistent with evidence from Pianngarn I et al.[33] and Siniscalchi A et al.[34], who demonstrated its efficacy in reducing opioid use and enhancing recovery. Tzimas P et al.[35] also supported epidural analgesia as the reference standard in hepatic ERAS programs. All patients received multimodal analgesia, including paracetamol, magnesium sulphate and dexamethasone, in line with Bennett et al.[36] and Huang Y et al.[37], who reported benefits in reducing opioid use and inflammatory response. Standardized antiemetic protocols were applied in 100% of cases, similar to Chiu C et al.[38], who showed reduced PONV rates with ERAS pathways, supported by Apfel et al.[39] who emphasized risk-based prophylaxis. Intraoperative complications were observed in 12.2% of cases, comparable to Magyar C et al.[40], who reported 8.6% adverse events. Blood loss >500 ml seen in some patients has been linked to higher morbidity and mortality by Bodur M et al.[41]. Post-extubation complications occurred in 23.1% of patients with PONV identified as a key factor (Apfel et al. [39]). Inotropic support was required in 8.1% of cases, aligning with Siniscalchi et al.[34] and Sommerfeld et al.[42], who reported vasopressor/inotrope use in 20–30% of major abdominal surgeries. Hong et al.[43] further highlighted that inotrope-based strategies may increase blood loss compared to vasopressor-based approaches, though without significant impact on overall outcomes.

In our study, normal recovery (<7 days) occurred in 64.9% of patients, similar to Yip VS et al.[44] and Moosburner S et al.[45], who reported discharge around day 6–7. Jones et al.[46] and Zhao Y et al.[47] further confirmed ERAS reduces hospital stay to 5–6 days compared with 8–9 days in standard care.

LIMITATIONS AND CLINICAL IMPLICATIONS

While this study demonstrates favorable outcomes with ERAS implementation in donor hepatectomy, several limitations should be acknowledged. The single-center design limits generalizability and the relatively small sample size may not detect all significant associations. The healthy donor population may not represent outcomes achievable in therapeutic hepatectomy patients with comorbidities and liver disease. Despite these limitations, the study provides valuable evidence supporting ERAS implementation in donor hepatectomy and highlights the critical role of comprehensive preoperative and intraoperative anesthetic management in achieving optimal outcomes. The results suggest that ERAS protocols can be safely and effectively implemented in this challenging surgical population with significant benefits in terms of recovery time, complication rates and resource utilization.

CONCLUSION

The present study demonstrates that structured pre- and intra-operative anaesthetic management based on ERAS protocols significantly support early recovery following hepatic resections. Most patients were young, ASA Grade I and underwent right hepatectomy with minimal comorbidities. Standard pre-operative care, including counselling, VTE prophylaxis and antibiotics was universally applied. Intraoperatively, stable maintenance of physiological parameters, multimodal analgesia and epidural anaesthesia contributed to favourable outcomes with intraoperative complications seen in only 12.2% of cases. Overall, 64.9% of patients achieved normal recovery within seven days, confirming the positive impact of ERAS-aligned anaesthetic practices on patient outcomes after hepatic surgery. Future research should focus on validating these findings in larger, multicenter studies and exploring the application of ERAS principles in therapeutic hepatectomy populations with greater comorbidity burdens and including post operative parametes. The continued evolution and refinement of ERAS protocols will likely yield further improvements in patient outcomes and healthcare resource utilization.

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