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ORIGINAL SCIENTIFIC REPORT

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Implementation and outcomes of an enhanced recovery after surgery pathway for laparoscopic cholecystectomy in East and Central Africa: A prospective non-randomized controlled trial in Rwanda's Tertiary Teaching Hospital

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Abstract

Background: Enhanced recovery after surgery (ERAS) programs have demonstrated efficacy in optimizing perioperative care and improving patient outcomes in various surgeries. However, their implementation and outcomes in resource-limited settings remain underexplored. This study aimed to assess the implementation of an ERAS protocol for laparoscopic cholecystectomy in such a setting.

Methods: This prospective non-randomized controlled trial involved 100 patients undergoing laparoscopic cholecystectomy at the University Teaching Hospital of Kigali, Rwanda. The first 50 patients on the ERAS pathway were prospectively evaluated and retrospectively compared to the last 50 patients operated on before ERAS implementation. Data on demographics, preoperative information, intraoperative compliance, postoperative events, and patient feedback were collected and analyzed.

Results: ERAS implementation resulted in a significant reduction in hospital length of stay (LOS) ($p < 0.001$) without increase in complications. Compliance with ERAS principles, including preoperative education and perioperative management, was more than 90%. ERAS also reduced costs due to quicker recovery and shorter hospital LOS.

Conclusion: The implementation of ERAS for laparoscopic cholecystectomy in a limited-resource setting is feasible and safe, suggesting the possibility of its potential adoption in other abdominal procedures. A high level of adherence to the ERAS pathway can be achieved with effective patient education and the dedication of healthcare providers.

KEYWORDS

enhanced recovery after surgery, laparoscopic cholecystectomy, perioperative care, postoperative outcomes

1 | INTRODUCTION

The enhanced recovery after surgery (ERAS) program represents a multimodal perioperative management approach aimed at a reduction of the surgical stress response and accelerate recovery of operated patients.[1,2] Central to ERAS protocols is the concept of targeting neurohormonal processes involved in the body's response to surgical stress, utilizing a standardized bundle of interventions to mitigate this stress and optimize patient's outcomes.[3–7]

In laparoscopic cholecystectomy, a common procedure in both developed and developing countries, ERAS pathways have demonstrated significant benefits including reduced postoperative morbidity, shortened length of hospital stay (length of stay (LOS)), and decreased overall healthcare costs.[8–10] However, the implementation of ERAS in laparoscopic cholecystectomy, particularly in resource-limited settings, presents unique challenges and opportunities. ERAS pathways for laparoscopic cholecystectomy emphasize patient's education, preoperative optimization, and setting realistic expectations. By actively involving patients in their own recovery process, ERAS protocols aim to enhance patient's autonomy and improve surgical outcomes.[8–10] ERAS protocols have been successfully implemented in various abdominal procedures and particularly in cholecystectomy.[11–17] Despite the proven benefits, including reduced LOS, faster recovery, and lower complication rates, the implementation of ERAS can be challenging due to perceived increased costs, the need for multidisciplinary coordination, and the adaptation of protocols to fit local resources and patient populations.

In Rwanda, following the successful establishment of a laparoscopy surgery program at the Centre Hospitalier Universitaire de Kigali (CHUK),[18] the authors hypothesized that integrating an ERAS pathway into this program could provide significant benefits to Rwandan patients undergoing laparoscopic cholecystectomy.

Given that laparoscopic cholecystectomy is the most frequently performed laparoscopic procedure at CHUK,[18] it was chosen as the initial focus for a modified and adapted ERAS protocol. The primary aim of this study was to prospectively evaluate the implementation and outcomes of a modified ERAS pathway for laparoscopic cholecystectomy in a resource-limited setting, with a specific focus on reducing the LOS to one day. Additionally, this study seeks to identify potential challenges and barriers specific to the Rwandan healthcare environment.

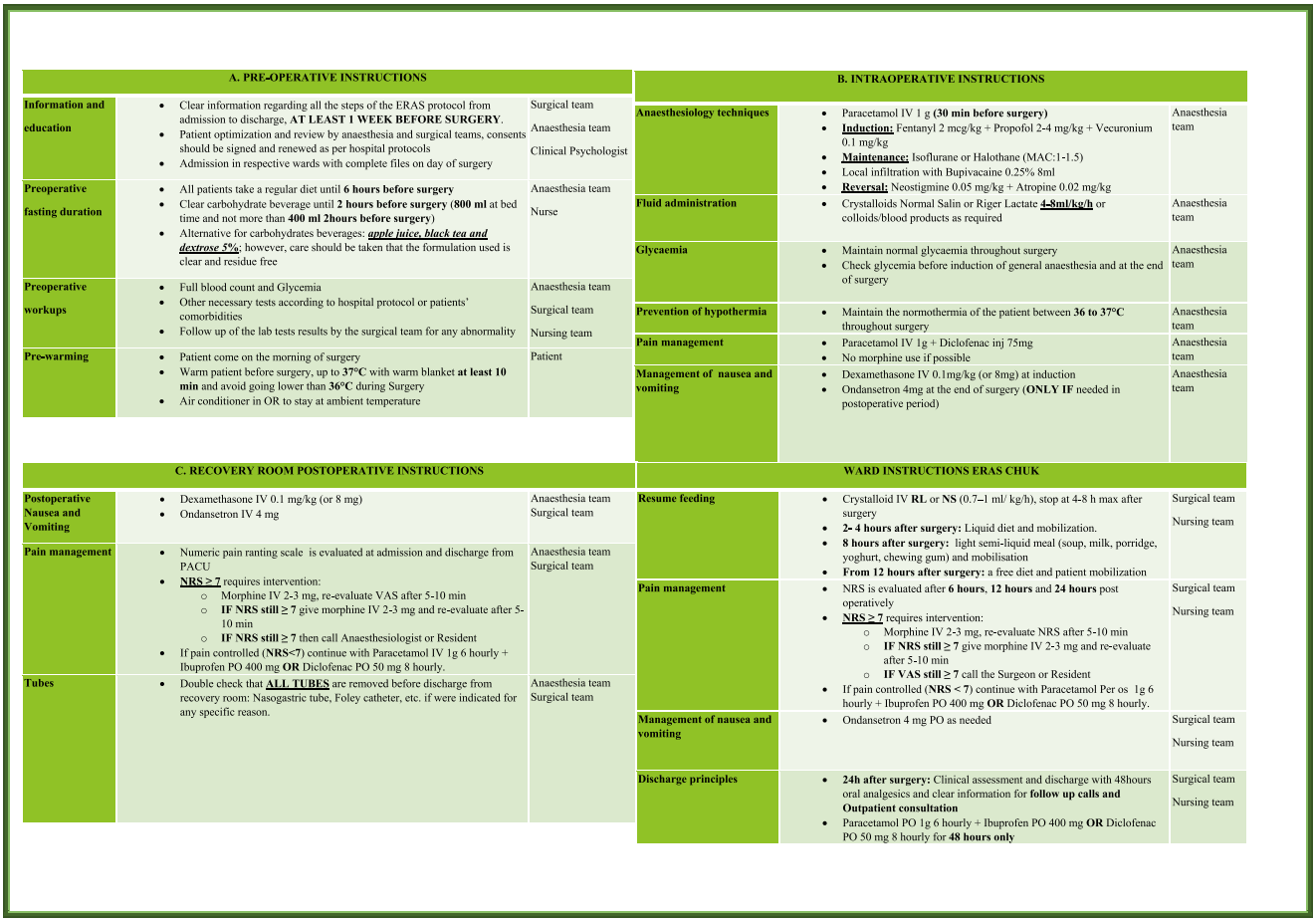
2 | MATERIAL AND METHODS

2.1 | Methods and setting

This non-randomized controlled trial prospectively studied the first 50 laparoscopic cholecystectomy patients managed according to a modified ERAS pathway (the ERAS group) implemented in the department of general surgery at CHUK, Rwanda, in January 2022 (Figure 1). Recognizing that specific ERAS guidelines for laparoscopic cholecystectomy do not exist, we developed a modified ERAS pathway tailored to our context, based on ERAS guidelines for elective abdominal surgery. The selection of elements for this pathway was informed by existing evidence, expert consensus, and the specific needs and constraints of our setting. These patients were retrospectively compared to the last 50 patients undergoing laparoscopic cholecystectomy before the implementation of the ERAS pathway (the control group) and who were prospectively included in the CHUK minimal invasive surgery (MIS) database according to the study reported by Nyundo et al.[18] This study was approved by both the Institutional Review Board (IRB) of the University of Rwanda and the Ethics Committee of CHUK with reference numbers No 412/CMHS IRB/2021 and EC/CHUK/1/074/2021, respectively, and was registered in ClinicalTrials.gov (NCT05516056). Informed consent was obtained from all patients participating to both groups. Information on the ERAS pathway was given by the surgeon or his assistant at a preoperative outpatient visit and confirmed by the theater nurse prior to surgery.

Inclusion criteria were all patients over 16-year of age undergoing elective laparoscopic cholecystectomy who consented for study participation. Exclusion criteria were urgent surgery or acute cholecystitis and American Society of Anesthesiology (ASA) class IV patients. Collected data encompassed demographics, ASA score, operative time, LOS, intraoperative events, postoperative adverse events, and postoperative complications. Postoperative complications were classified according to the Clavien–Dindo classification system up to postoperative day 90.[19] For the cost analysis, data on six primary cost drivers were gathered: surgical acts, anesthesia acts, nursing acts, consumables, drugs/medications, and hospitalization. The direct costs associated with each driver were obtained from the national health services tariff of the hospital. The total direct cost per patient was calculated by summing the costs across these six drivers, and the mean direct surgical cost of laparoscopic cholecystectomy was then determined. This straightforward summation method provided an overview of the direct financial implications of implementing the ERAS pathway, although it did not extend into more complex cost analyses.

Postoperative patient impressions and satisfaction were assessed using the Likert scale. The numeric rating scale was used to assess the postoperative pain.[20] Primary outcomes included hospital LOS and postoperative complications. Secondary outcomes comprised surgical care direct costs, adherence to all elements of the modified ERAS pathway, and patient satisfaction. Compliance with the modified ERAS pathway was specifically measured for all elements of our protocol. Data



A. PRE-OPERATIVE INSTRUCTIONS

Information and education	• Clear information regarding all the steps of the ERAS protocol from admission to discharge, **AT LEAST 1 WEEK BEFORE SURGERY**. • Patient optimization and review by anaesthesia and surgical teams, consents should be signed and renewed as per hospital protocols • Admission in respective wards with complete files on day of surgery	Surgical team Anaesthesia team Clinical Psychologist
Preoperative fasting duration	• All patients take a regular diet until **6 hours before surgery** • Clear carbohydrate beverage until **2 hours before surgery** (**800 ml** at bed time and not more than **400 ml 2hours before surgery**) • Alternative for carbohydrates beverages: ***apple juice, black tea and dextrose 5%***; however, care should be taken that the formulation used is clear and residue free	Anaesthesia team Nurse
Preoperative workups	• Full blood count and Glycemia • Other necessary tests according to hospital protocol or patients' comorbidities • Follow up of the lab tests results by the surgical team for any abnormality	Anaesthesia team Surgical team Nursing team
Pre-warming	• Patient come on the morning of surgery • Warm patient before surgery, up to **37°C** with warm blanket **at least 10 min** and avoid going lower than **36°C** during Surgery • Air conditioner in OR to stay at ambient temperature	Patient

B. INTRAOPERATIVE INSTRUCTIONS

Anaesthesiology techniques	• Paracetamol IV 1 g (**30 min before surgery**) • **Induction:** Fentanyl 2 mcg/kg + Propofol 2-4 mg/kg + Vecuronium 0.1 mg/kg • **Maintenance:** Isoflurane or Halothane (MAC:1-1.5) • Local infiltration with Bupivacaine 0.25% 8ml • **Reversal:** Neostigmine 0.05 mg/kg + Atropine 0.02 mg/kg	Anaesthesia team
Fluid administration	• Crystalloids Normal Salin or Riger Lactate **4-8ml/kg/h** or colloids/blood products as required	Anaesthesia team
Glycaemia	• Maintain normal glycaemia throughout surgery • Check glycemia before induction of general anaesthesia and at the end of surgery	Anaesthesia team
Prevention of hypothermia	• Maintain the normothermia of the patient between **36 to 37°C** throughout surgery	Anaesthesia team
Pain management	• Paracetamol IV 1g + Diclofenac inj 75mg • No morphine use if possible	Anaesthesia team
Management of nausea and vomiting	• Dexamethasone IV 0.1mg/kg (or 8mg) at induction • Ondansetron 4mg at the end of surgery (**ONLY IF** needed in postoperative period)	Anaesthesia team

C. RECOVERY ROOM POSTOPERATIVE INSTRUCTIONS

Postoperative Nausea and Vomiting	• Dexamethasone IV 0.1 mg/kg (or 8 mg) • Ondansetron IV 4 mg	Anaesthesia team Surgical team
Pain management	• Numeric pain ranting scale is evaluated at admission and discharge from PACU • **NRS ≥ 7** requires intervention: ○ Morphine IV 2-3 mg, re-evaluate VAS after 5-10 min ○ **IF NRS still ≥ 7** give morphine IV 2-3 mg and re-evaluate after 5-10 min ○ **IF NRS still ≥ 7** then call Anaesthesiologist or Resident • If pain controlled (**NRS<7**) continue with Paracetamol IV 1g 6 hourly + Ibuprofen PO 400 mg **OR** Diclofenac PO 50 mg 8 hourly.	Anaesthesia team Surgical team
Tubes	• Double check that **ALL TUBES** are removed before discharge from recovery room: Nasogastric tube, Foley catheter, etc. if were indicated for any specific reason.	Anaesthesia team Surgical team

WARD INSTRUCTIONS ERAS CHUK

Resume feeding	• Crystalloid IV **RL** or **NS** (0.7–1 ml/ kg/h), stop at 4-8 h max after surgery • **2- 4 hours after surgery:** Liquid diet and mobilization. • **8 hours after surgery:** light semi-liquid meal (soup, milk, porridge, yoghurt, chewing gum) and mobilisation • **From 12 hours after surgery:** a free diet and patient mobilization	Surgical team Nursing team
Pain management	• NRS is evaluated after **6 hours**, **12 hours** and **24 hours** post operatively • **NRS ≥ 7** requires intervention: ○ Morphine IV 2-3 mg, re-evaluate NRS after 5-10 min ○ **IF NRS still ≥ 7** give morphine IV 2-3 mg and re-evaluate after 5-10 min ○ **IF VAS still ≥ 7** call the Surgeon or Resident • If pain controlled (**NRS < 7**) continue with Paracetamol Per os 1g 6 hourly + Ibuprofen PO 400 mg **OR** Diclofenac PO 50 mg 8 hourly.	Surgical team Nursing team
Management of nausea and vomiting	• Ondansetron 4 mg PO as needed	Surgical team Nursing team
Discharge principles	• **24h after surgery:** Clinical assessment and discharge with 48hours oral analgesics and clear information for **follow up calls and Outpatient consultation** • Paracetamol PO 1g 6 hourly + Ibuprofen PO 400 mg **OR** Diclofenac PO 50 mg 8 hourly for **48 hours only**	Surgical team Nursing team

FIGURE 1 Modified enhanced recovery after the surgery pathway for cholecystectomy at the Centre Hospitalier Universitaire de Kigali (CHUK), Kigali, Rwanda.

on adherence were collated using a checklist completed by the perioperative team, with oversight from a surgical resident to ensure the checklist was fully completed and to minimize missing data.

After discharge, patients were followed up via phone and/or outpatient consultations on days 3, 7, 15, 30, and 90. No patients were lost to follow-up by day 90.

2.2 | Statistical analysis

Continuous variables, such as operative time and LOS, are presented as median [interquartile range] and were compared between groups using the Mann–Whitney *U* test. Categorical variables, including demographics and ASA scores, were analyzed using chi-squared tests or Fisher's exact tests, as appropriate, and are presented as percentages. The classification of postoperative complications followed the Clavien–Dindo classification, which was used to assess and compare outcomes between the ERAS and control groups. For the cost study, only the direct prices of the cost drivers were utilized and these were summed to calculate the total direct cost per patient. The mean direct surgical cost was then compared between the ERAS and control groups.

Based on a pre-ERAS LOS of 3 days, a sample size calculation determined that 48 patients per group would be needed to detect a significant reduction in LOS to one day, with a significance level of 0.05% and 90% power (standard deviation: 3 days). Statistical analyses were conducted using Prism 9.5.1 for Mac.

3 | RESULTS

3.1 | Patient characteristics

Table 1 shows that there were no detected significant differences between control and ERAS groups including in age, ASA class, and comorbidities.

3.2 | Primary outcomes

The median LOS was 1 day in the ERAS group, ranging from 1 to 4 days, with 96% of the patients successfully discharged on the first day after surgery. In the control group, median LOS was 3 days ($p < 0.0001$) (Table 2). There was no difference in operative time, intraoperative events, conversion to open surgery, or post

TABLE 1 Characteristics of study participants.

Characteristics	Control group ($n = 50$)	ERAS group ($n = 50$)	p value
Sex ratio (Females/Males)	43/7	40/10	0.59
Age (years)	51.5 (39–62)	46 (39.7–62.5)	0.56
Comorbidities			0.50
Hypertension	10 (20%)	7 (14%)	
HIV	2 (4%)	4 (8%)	
Diabetes	4 (8%)	3 (6%)	
Hepatitis B virus	0 (0%)	1(2%)	
Hepatitis C virus	0 (0%)	1 (2%)	
Previous abdominal surgery	7 (14%)	14 (28%)	0.13
ASA class			0.54
ASA 1	27 (54%)	31 (62%)	
ASA 2	23 (46%)	19 (38%)	

Note: Data are presented as absolute numbers (percentages) or as median (IQR).

Abbreviations: ASA, American Society of Anesthesiology; ERAS, enhanced recovery after surgery; HIV, human immunodeficiency virus; IQR, interquartile range.

operative complications (Table 2). Patients included in the ERAS pathway reported less nausea, anxiety, tiredness, and pain. Two patients (4%) from the ERAS group were readmitted in hospitalization for pain ($n = 1$ and 2%) and for pneumonia ($n = 1$ and 2%).

3.3 | Secondary outcomes

The overall direct surgical costs of a laparoscopic cholecystectomy were significantly lower in the ERAS group compared to the control group ($p < 0.0001$) (Table 2). In the ERAS group, all patients received information about the ERAS pathway including on pain management, perioperative fasting, and discharge plan with education on home medication (Table 3). One patient did not receive the information about the management of postoperative nausea and vomiting. The perioperative fasting plan was respected in 90% of the cases, and among the 5 patients who did not follow the fasting plan, 4 of them were afraid, whereas one reported personal reason (Table 3).

Throughout the surgical procedures, all patients were stable with hemodynamic, temperature, and blood sugar parameters within normal. Multimodal analgesia was respected for all patients but one, and 13 (26%) patients were reported to receive additional opioids because the anesthesiologist considered it necessary (Table 4). Almost all patients (98%) received dexamethasone, whereas 11 patients (22%) received additional ondansetron to prevent nausea and vomiting. Forty-three patients (86%) received infiltration of the surgical wounds with local anesthetics (Table 4).

Early movement and feeding were respected by most of patients under the ERAS protocol. The assessment prior to discharge revealed that all patients started to move, whereas 94% started to eat usual meals on postoperative day one and only one patient remained on antiemetic treatment. No patients reported severe pain on postoperative day one, even if 40% were still complaining of pain. All patients, except one received post-discharge follow-up information and education with a compliance of 98% (Table 5).

Table 6 shows that the consequences of the surgery regressed with time. On postoperative day 7, one pneumonia and one surgical site infection were diagnosed. Some symptoms rarely persisted until day 30 including pain (4%), fatigue (2%), and nausea (2%) (Table 6).

Most of patients (96%) agreed or strongly agreed that the ERAS protocol was clearly explained to them by medical staff during admission, during the surgical process, and after the operation, and about 70% of them disagreed or strongly disagreed with the statement that discharge the next day after laparoscopic cholecystectomy is dangerous, whereas 30% of patients considered that it is dangerous even if they did not encounter any complications. Importantly, 98% of patients were satisfied with the process of the ERAS pathway and their experience of surgery (Table 7).

4 | DISCUSSION

This study aimed to evaluate the implementation and outcomes of the ERAS protocol for laparoscopic cholecystectomy in a resource-limited Sub-Saharan country. This study demonstrated that the implementation of an ERAS protocol is both feasible and safe in an academic hospital in Rwanda, with high acceptance and adherence by both patients and medical staff. Cholecystectomy was

TABLE 2 Comparison of outcomes between groups.

Outcome	Control group ($n = 50$)	ERAS group ($n = 50$)	p value
LOS (days)	3 (2–3.2)	1 (1–1)	<0.0001
Operative time (min)	80 (60–120)	70 (60–104.8)	0.82
Intraoperative events	4 (8%)	11 (22%)	0.052
Gallbladder perforation	1 (2%)	8 (16%)	
Common bile duct injury	1 (2%)	1 (2%)	
Bleeding	1 (2%)	1 (2%)	
Bradycardia	0 (0%)	1 (2%)	
Bowel perforation	1 (2%)	0 (0%)	
Conversion	0 (0%)	0 (0%)	
Postoperative events	92	38	
Nausea	23 (46%)	7 (14%)	<0.001
Anxiety	16 (32%)	0 (0%)	<0.0001
Tiredness	21 (42%)	12 (24%)	0.08
Pain	32 (64%)	19 (38%)	0.12
Postoperative complications	3	2	>0.99
Grade 1	2 (4%)	1 (2%)	
Grade 2	0 (0%)	1 (2%)	
Grade 3	1 (2%)	0 (0%)	
Overall costs (RWF)	276,825 (224,448–361,366)	137,461 (114,195–173,682)	<0.0001
Readmissions	0 (0%)	2 (4%)	0.49

Note: Data are presented as absolute numbers (percentages) or as median (IQR).
Abbreviations: ERAS, enhanced recovery after surgery; IQR, interquartile range; LOS, length of stay; RWF, Rwandan Francs.

TABLE 3 Preoperative education and counseling.

	Shared information of the ERAS group ($N = 50$)	Verification before surgery of the ERAS group ($n = 50$)
Information on the pain management	50 (100%)	50 (100%)
Information on the preoperative fasting	50 (100%)	50 (100%)
Information on the prevention of nausea and vomiting	49 (98%)	49 (98%)
Information on discharge plan, education, and home medications	50 (100%)	49 (98%)

Note: Data are presented as absolute numbers (percentages).
Abbreviation: ERAS, enhanced recovery after surgery.

chosen as it is the most performed MIS procedure in Rwanda[18] and in Africa.[21] This work builds upon the pioneering efforts of Dr. Ravi Oodit, who has been instrumental in adapting and promoting perioperative care and ERAS guidelines for low- and middle-income countries as highlighted in his contributions to the field.[22,23]

This ERAS protocol made it possible to significantly reduce the length of hospitalization and the cost of laparoscopic cholecystectomy, without an increase in postoperative complications, and with great patient satisfaction. These results align with literature demonstrating ERAS benefits in reducing hospital LOS and complications.[5,6,14,16,24,25] Although adverse intraoperative events showed no different between groups, postoperative nausea and anxiety were lower in the ERAS group with a similar rate of complications, consistent with the safety profile of ERAS in minimizing adverse outcomes.[26]

This study is original because ERAS pathways are very rarely implemented in Sub-Saharan African countries. The tradition of open surgery and long

TABLE 4 Intraoperative compliance to the enhanced recovery after surgery protocol.

	***n* = 50**
Glycemia prior to induction (mg/dl)	103.5 (89–115)
Temperature (°C)	36.3 (36–35.5)
Normovolemia	48 (96%)
Multimodal analgesics	49 (98%)
Additional opioids (morphine)	13 (26%)
Dexamethasone	49 (98%)
Additional ondansetron	11 (22%)
Wound infiltration with local anesthetics	43 (86%)

Note: Data are presented as absolute numbers (percentages) or as median (IQR).

Abbreviations: ERAS, enhanced recovery after surgery; IQR, interquartile range.

TABLE 5 Discharge assessment and clinical events within the enhanced recovery after the surgery group.

Events during day 1 postoperative period	***n* = 50**
Normal vital signs (Temp, BP, RR, and HB)	49 (98%)
Early mobilization	50 (100%)
Started usual meals	47 (94%)
Need for antiemetic treatment	1 (2%)
Reported pain	20 (40%)
Mild pain	13 (26%)
Moderate pain	7 (14%)
Severe pain	0 (0%)
Post-discharge information and education	49 (98%)

Note: Data are presented as absolute numbers (percentages).

Abbreviations: BP, blood pressure; ERAS, enhanced recovery after surgery; HB, heartbeats; RR, respiratory rate; Temp, temperature.

hospitalization remains anchored both in the medical and paramedical profession and among patients. After setting up a laparoscopic surgery program, the authors aimed to reduce LOS for cholecystectomy by switching to an ERAS program. This type of program changes the routine of healthcare professionals and patients, with the need for educational sessions explaining the reason of these changes and the advantages of ERAS-type care. Patient information is essential and the key to the success of this approach. In this study, we observed remarkable adherence to the ERAS protocol among both patients and among the healthcare professionals, a feat not initially anticipated and previously unreported in Sub-Saharan countries. This information plays a crucial role in promoting ERAS adherence, optimizing perioperative care, and improving surgical outcomes[6,26], and other studies supported that patient education is related to a reduction in hospital stays and complications.[27–29] Interventions, such as preoperative carbohydrate loading and pre-warming, have shown to reduce hospital LOS and improve postoperative outcomes[30,31], and recent studies highlighted that higher adherence to the ERAS protocol may be correlated with a reduction in mortality[8] and also improved 5-year survival after colon surgery.[32] Furthermore, the observed rates of adverse events (20%) and postoperative pain (30%) of this study align with previous literature, with multimodal analgesia administration and early initiation of feeding and mobilization contributing to improved patient outcomes.[33–35] Intraoperative management closely adhered to ERAS principles, maintaining normal hemodynamic and temperature, whereas multimodal analgesia effectively controlled pain in almost all patients.[36,37] Widespread administration of anti-nausea medication aimed at reducing postoperative nausea and vomiting was observed, consistent with evidence-based practices reporting that intraoperative use of glucocorticoids is effective for postoperative nausea and vomiting prophylaxis and can also provide early postoperative analgesic effects.[38–41]

The study findings highlight several key aspects of the discharge process and post-discharge follow-up in the ERAS protocol. Patient perceptions regarding early discharge varied, with the majority agreeing that it is not dangerous, but 30% expressing the need for further education and reassurance. Several studies underscore the importance of patient education and engagement throughout the perioperative period, including post-discharge follow-up, to optimize recovery and reduce readmission rates.[42,43] Evidence suggests that early discharge after surgery is not associated with an increase in readmissions or post-discharge complications, supporting the safety and feasibility of early discharge within ERAS programs. Others highlight the role of patient-centered care in enhancing postoperative outcomes, which encompasses ongoing communication and support after discharge.[9,44,45] Advocating for the use of telemedicine and remote monitoring technologies aligns with the overarching goal of optimizing post-discharge care and reducing readmissions within ERAS programs.[46] Addressing patient concerns through clear communication, education about postoperative recovery expectations, and providing support during the transition to home can help alleviate fears and improve patient acceptance of early discharge within ERAS programs.

In laparoscopy, the cost of surgery greatly depends on the availability of laparoscopic equipment and reusable or disposable instruments. These costs were not different between the control group and the ERAS group. The additional cost associated with modern medications and perioperative multimodal care results in an additional cost in the ERAS group, offset by the reduction in costs associated with a shorter

TABLE 6 Post-discharge symptoms and events among the enhanced recovery after surgery group.

	n = 50				
Events	**Day 3**	**Day 7**	**Day 15**	**Day 30**	**Day 90**
Pain	23 (46%)	10 (20%)	6 (12%)	2 (4%)	0 (0%)
Tiredness/Fatigue	12 (24%)	6 (12%)	4 (8%)	1 (2%)	0 (0%)
Nausea	0 (0%)	0 (0%)	1 (2%)	1 (2%)	0 (0%)
Vomiting	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Post-discharge complications	0 (0%)	2 (4%)	1 (2%)	0 (0%)	0 (0%)

TABLE 7 Patients' feedback on enhanced recovery after surgery pathway.

	***n* = 50**
Protocol clearly explained by medical staff	
Strongly agree	36 (72%)
Agree	12 (24%)
Neutral	2 (4%)
Disagree	0 (0%)
Strongly disagree	0 (0%)
Discharge one day after laparoscopic cholecystectomy is dangerous	
Strongly agree	8 (16%)
Agree	6 (12%)
Neutral	1 (2%)
Disagree	10 (20%)
Strongly disagree	25 (50%)
General satisfaction	
Satisfied	49 (98%)
Neutral	1 (2%)

Note: Data are presented as absolute numbers (percentages).
Abbreviation: ERAS, enhanced recovery after surgery.

hospitalization and the savings on the cost of medications required in prolonged hospitalization. Compared to the Western world, the cost per day of hospitalization is lower in a low-income country as Rwanda, but even in Rwanda, the LOS reduction linked to the ERAS program can be a cost saving. Existing literature supports ERAS cost-effectiveness in various surgical procedures, despite initial higher costs. Implementing ERAS may lead to higher upfront costs but is offset by decreased length of hospital stay and reduced complication rates, resulting in long-term cost savings. These findings underscore ERAS effectiveness in reducing hospital stays, complications rates resulting in long-term cost savings compared to traditional care pathways.[5,16,47,48] Additionally, it is noted that the treatment cost typically peaks in the first days after admission, emphasizing the importance of interventions such as ERAS in optimizing resource utilization and reducing overall healthcare costs.[4]

The main limitation of this study is the absence of randomization, but randomization of a new medical pathway is difficult and nowadays impossible, as ERAS rapidly became the standard of care for laparoscopic cholecystectomy at CHUK. Another limitation is the fact that laparoscopic cholecystectomy is a procedure for which it seems easier to propose early mobilization and feeding, compared to colon surgery. However, even in cholecystectomy, the ERAS pathway meant a total change of clinical practice that is particularly difficult in a low-income Sub-Saharan country as Rwanda. As a first step in modern perioperative management, the ERAS pathway in laparoscopic cholecystectomy paved the way to other indications as in colon surgery. This is particularly important as cholecystectomy is the most frequently performed laparoscopic abdominal procedure in Africa.

In conclusion, this study highlighted ERAS benefits for laparoscopic cholecystectomy in resource-limited settings. Thanks to a high protocol adherence, ERAS allowed shorter hospital stays, reduced costs, and enhanced perioperative care and outcomes. Laparoscopic cholecystectomy may serve as a model for ERAS adoption in resource-limited settings, improving surgical care delivery and resource utilization.

AUTHOR CONTRIBUTIONS

Martin Nyundo: Conceptualization; Data curation; Formal analysis; Funding acquisition; Methodology; Project administration; Resources; Supervision; Validation; Visualization; Writing - original draft; Writing - review & editing. **King Kayondo**: Conceptualization; Methodology; Supervision; Validation; Visualization; Writing - original draft; Writing - review & editing. **Miguel Gasakure**: Data curation; Formal analysis; Investigation; Supervision; Validation; Visualization; Writing - original draft. **Jean Damascene Twagirumukiza**: Data curation; Formal analysis; Software; Validation; Visualization; Writing - original draft. **Julien Gashegu**: Conceptualization; Data curation; Supervision; Validation; Visualization; Writing - original draft; Writing - review & editing. **Olivier Detry**: Conceptualization; Data curation; Formal analysis; Methodology; Software;

Supervision; Validation; Visualization; Writing - original draft; Writing - review & editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data supporting this study's findings are not publicly available due to restrictions based on patient privacy and confidentiality. However the data may be available by the corresponding author upon reasonable request and with the permission of the hospital's review board. Access to the data will require an approved request in accordance with institutional and ethical guidelines.

ETHICS STATEMENT

The IRB of the University of Rwanda (412/CMHS IRB/2021) and the Ethics Committee of the University Teaching Hospital of Kigali (EC/CHUK/1/074/2021) approved this study that was registered in ClinicalTrials.gov (NCT05516056).

INFORMED CONSENT

Informed consent was obtained from all individual participants included in the study.

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