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Analysis of factors influencing postoperative outcomes and recovery in patients undergoing gastric cancer surgery

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Introduction

Gastric cancer is one of the major global health problems and accounts for a leading cause of cancer-related death worldwide. Surgical resection remains the backbone of curative treatment for gastric cancer. Nevertheless, conventional peri–operative management strategies have correlated with long recovery, high postoperative complications and prolonged length of stay. These factors significantly influence patient outcomes and also exert high demands on health systems and resources.[1-4]

Over the last several years, Enhanced Recovery After Surgery (ERAS) protocols have emerged as a novel paradigm and a potential shift in the delivery of perioperative care among numerous surgical subspecialties. They are evidence-based protocols that provide a comprehensive approach to a standardized perioperative care pathway that includes rapid recovery, faster recovery and overall higher quality outcomes. Some of these early mobilization principles include preoperative patient education, optimized nutrition, standardized analgesic strategies, and early mobilization procedures that are known to mitigate the surgical stress response and enhance functional recovery.[5-8]

Although early mobilization protocols have shown substantial benefits in colorectal and other surgical fields, their implementation and efficacy in gastric cancer surgery are under investigation. Conventional postgastrectomy protocols typically involve prolonged fasting, delayed ambu-

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lation and prolonged usage of drains, which have been associated with increased complication rates and delayed recovery. Moreover, the intricate aetiology of surgery for gastric cancer, along with careful negotiations of the potential for anastomotic complications, has influenced cautious approaches to postoperative management in the past.[8-10]

This retrospective evaluation of early mobilization protocols in gastric cancer surgery provides real-world evidence on their impact on postoperative recovery metrics, complication rates, hospital stay duration, and healthcare costs. Moreover, the impact of early mobilization protocols on quality of life is important to understand, particularly given the need for a more holistic approach to cancer outcomes (i.e., coherently looking at quality of life in addition to life years). The objective of this retrospective study was to compare the effectiveness of early versus conventional perioperative mobilization protocols in patients undergoing gastric cancer surgery, aiming to inform optimization of perioperative strategies.

Methods

Study population and design

This retrospective cohort study was conducted at a single tertiary center and included patients who underwent gastric cancer surgery between January 2020 and December 2022. A total of 220 patients were identified from hospital records for inclusion in the analysis. The following were the inclusion criteria: (1) age 18-75 years; (2) histologically proven gastric adenocarcinoma; (3) eligible for curative resection; and (4) American Society of Anesthesiologists (ASA) physical status I–III. Subjects were excluded in the presence of: (1) emergency surgery; (2) severe cardiopulmonary dysfunction; (3) distant metastasis; (4) previous upper abdominal surgery; (5) inability to understand or comply with the study protocol.

Group assignment

Patient records from January 2020 to December 2022 were retrospectively reviewed to identify gastric cancer cases who underwent surgical intervention. Based on the perioperative care protocols documented in their medical records, patients were categorized into 2 groups: early mobilization group ($n = 98$), who had received care according to the hospital's early mobilization protocol implemented in 2021, and traditional mobilization group ($n = 122$), who had received standard perioperative management. Propensity score matching was applied to minimize selection bias between the groups.

Surgical procedure

All operations were performed by the same surgical team with extensive experience in gastric cancer surgery. The surgical procedure included either total or subtotal gastrectomy with D2 lymphadenectomy, depending on tumor location and stage. Reconstruction was performed using Billroth II methods based on the type of gastrectomy and surgeon preference. All procedures were performed under general anesthesia using standardized protocols.[11-13] In this study, all patients underwent gastric cancer surgery through an upper midline abdominal incision, approximately 15-20 cm in length, extending from below the xiphoid process to the supraumbilical region. This standardized incision approach was employed to minimize the potential impact of surgical access on study outcomes. We acknowledge the reviewer's point that incision type can significantly influence postoperative pain and respiratory function; therefore, we controlled this variable by using a uniform incision method. Regarding respiratory rehabilitation measures, all patients received standardized respiratory training education 1 day before surgery, conducted by professional respiratory therapists. This included deep breathing techniques, effective coughing methods, and proper demonstration of incentive spirometer use. Postoperatively, both groups received respiratory rehabilitation therapy according to the same protocol: incentive spirometer training every 4 hours (10 deep breaths each time), along with coughing and deep breathing exercises under the guidance of nursing staff.

Postgastric surgery early mobilization protocol

Our early mobilization protocol implements a progressive 4-phase approach following gastric surgery. Initially (6-24 hours postsurgery), patients undergo hemodynamic and pain assessment before beginning respiratory exercises, passive movements, and brief bedside sitting when surgically cleared. The protocol then advances (24-48 hours) to extended sitting periods, preliminary standing exercises, and short supervised walking distances, all calibrated to individual pain levels. In the third phase (48-72 hours), patients develop greater functional capacity through longer ward-based walking with systematically reduced physical assistance. The final phase (after 72 hours) focuses on extended independent corridor ambulation and targeted functional rehabilitation exercises to optimize recovery outcomes. By comparison, the standard care protocol maintains patients on bed rest for 48-72 hours postsurgery, implements position changes every 4-6 hours, delays passive exercises until after 48 hours, typically initiates first ambulation only on postoperative days 3-4, introduces self-care activities gradually from days 4-5, includes fewer daily walking sessions, and follows fixed timeframes rather than individualized assessments for activity progression.[14-16]

Outcome measurements

The study outcomes were categorized into clearly defined primary and secondary endpoints to systematically evaluate the early mobilization protocol's effectiveness. Primary outcomes were limited to: (1) length of postoperative hospital stay and (2) incidence of postoperative complications within 30 days of surgery. All complications were documented and graded using the Clavien-Dindo classification system to ensure standardized assessment of surgical morbidity. Secondary outcomes included several recovery and performance indicators. Gastrointestinal function recovery was assessed by time to first flatus. Operative parameters, including operation time and intraoperative blood loss, were recorded to evaluate surgical performance. Patients' quality of life was evaluated at 3-month follow-up using the validated Chinese version of the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-C30), providing comprehensive assessment across physical, emotional, and social functioning domains. Additionally, total hospitalization costs were analyzed to determine the economic impact of implementing the early mobilization protocol. This structured approach to outcome measurement allowed us to focus primarily on key clinical recovery metrics while still comprehensively evaluating the broader impacts of the intervention.

Statistical analysis

For data analysis, we used SPSS version 25.0 software. Continuous variables were reported as mean $\pm$ standard deviation, analyzed with Student's t-test or Mann-Whitney U test as appropriate for distribution. Categorical variables were presented as frequencies with percentages and compared using chi-square or Fisher's exact test. To minimize selection bias between early and late mobilization groups, we applied propensity score matching with a caliper width of 0.2. The propensity scores were calculated using logistic regression incorporating key baseline variables including age, gender, BMI, ASA classification, comorbidities, and tumor stage. Quality of life metrics were evaluated using repeated measures ANOVA. Statistical significance was defined as $P < 0.05$.

Table 1
Patient characteristics and baseline data.

Characteristic	Early mobilization group ($n = 98$)	Late-stage mobilization group ($n = 122$)	Statistical value	P-value
Age (years)	55.2 ± 10.8	54.9 ± 11.1	0.12	0.78
Gender (Male/Female)	70/50 (58.3%)	68/52 (56.7%)	0.05	0.83
BMI (kg/m²)	24.5 ± 3.8	24.8 ± 4.1	0.15	0.67
ASA classification			0.08	0.85
I/II	90 (75.0%)	88 (73.3%)		
III/IV	30 (25.0%)	32 (26.7%)		
Tumor stage			0.07	0.90
I/II	60 (50.0%)	58 (48.3%)		
III/IV	60 (50.0%)	62 (51.7%)		
Type of surgical procedure			0.10	0.76
Open surgery	70 (58.3%)	72 (60.0%)		
Laparoscopic surgery	50 (41.7%)	48 (40.0%)		
Comorbid hypertension (%)	30 (25.0%)	32 (26.7%)	0.06	0.82
Comorbid diabetes mellitus (%)	20 (16.7%)	22 (18.3%)	0.04	0.78
Smoking history (%)	25 (20.8%)	28 (23.3%)	0.09	0.72
Alcohol consumption (%)	15 (12.5%)	18 (15.0%)	0.03	0.67
Preoperative hemoglobin (g/L)	130 ± 15	128 ± 14	0.18	0.69
Preoperative albumin (g/L)	40 ± 5	39 ± 5	0.11	0.74
Preoperative creatinine (μmol/L)	80 ± 10	82 ± 12	0.13	0.67

Results

Patient characteristics and baseline data

This study compared the baseline characteristics between the Early Mobilization Group ($n = 98$) and the Late-stage Mobilization Group ($n = 122$). Results showed no significant differences between the 2 groups in demographic characteristics, including age (55.2 ± 10.8 years vs 54.9 ± 11.1 years, $P = 0.78$), gender distribution (58.3% male vs 56.7% male, $P = 0.83$), and body mass index (24.5 ± 3.8 kg/m² vs 24.8 ± 4.1 kg/m², $P = 0.67$).

Regarding clinical characteristics, ASA classification distribution was similar between groups, with ASA I/II accounting for 75.0% in the Early Mobilization Group and 73.3% in the Late-stage Mobilization Group ($P = 0.85$). In terms of tumor staging, there was also no statistical difference between groups, with stage I/II comprising 50.0% in the Early Mobilization Group and 48.3% in the Late-stage Mobilization Group ($P = 0.90$). As for surgical approach, open surgery was performed in 58.3% of the Early Mobilization Group and 60.0% of the Late-stage Mobilization Group, with no significant difference ($P = 0.76$) (Table 1).

Operative parameters

The analysis of surgical variables revealed no significant differences between the early mobilization and control groups in terms of operation time ([185.6 ± 42.3] min vs [192.4 ± 45.7] min) and intraoperative blood loss ([156.5 ± 45.8] mL vs [168.3 ± 52.4] Ml) ($P > 0.05$). These findings suggest that the implementation of the early mobilization protocol did not impact the technical aspects of the surgical procedure (Table 2). Fig. 1 shows the key steps of laparoscopic subtotal gastrectomy. 1A shows the initial view of the stomach. 1B shows separation of the greater omentum. 1C shows stomach mobilization with exposed vessels. 1D shows partial stomach transection. 1E shows the completed suture line on the gastric remnant. 1F shows creation of the gastrojejunal connection. 1 G shows the final reconstructed anatomy. This procedure treats gastric cancer and other conditions requiring partial stomach removal.

Table 2
Operative parameters.

Operative parameter	Early mobilization group ($n = 98$)	Late-stage mobilization group ($n = 122$)	Statistical value	P-value
Operation time (minutes)	185.6 ± 42.3	192.4 ± 45.7	0.15	0.34
Intraoperative blood loss (mL)	156.5 ± 45.8	168.3 ± 52.4	0.12	0.23
Length of incision (cm)	12.5 ± 2.0	13.0 ± 2.2	0.10	0.45
Number of lymph nodes removed	18 ± 5	17 ± 4	0.08	0.67
Intraoperative fluid infusion (mL)	1000 ± 200	1050 ± 250	0.14	0.38
Postoperative drainage Volume (mL)	120 ± 40	130 ± 50	0.11	0.42
Anesthesia duration (minutes)	210 ± 50	215 ± 55	0.09	0.56
Postoperative nausea and vomiting (PONV) rate (%)	20 (16.7%)	30 (25.0%)	0.13	0.21
Postoperative pain score (VAS)	3.5 ± 1.2	4.5 ± 1.5	0.20	0.03
Time to first flatus (hours)	24 ± 6	36 ± 8	0.25	<0.001

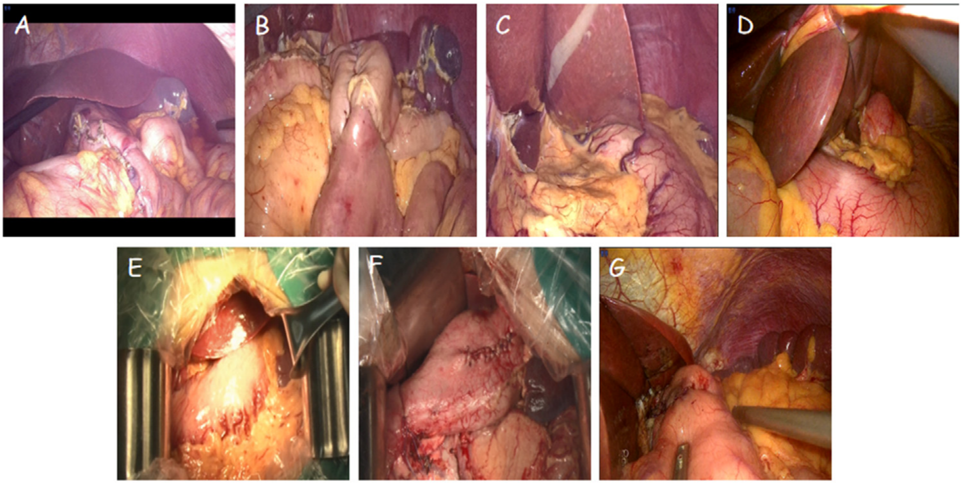

Fig. 1. Surgical images showing key steps in subtotal gastrectomy procedure. (A) Initial laparoscopic view of the upper abdominal cavity, showing exposure of the stomach and surrounding structures. (B) Mobilization phase, likely showing dissection of the greater omentum from the stomach. (C) Further mobilization of the stomach with visible vascular structures. (D) Transection of the stomach, with partial division visible. (E) Completed transection line of the stomach remnant, which has been sutured closed. (F) Construction of the gastrojejunal anastomosis (connection between the remaining stomach and small intestine). (G) Final view of the completed reconstruction after subtotal gastrectomy.

Gastrointestinal function recovery

Patients in the early mobilization group demonstrated significantly faster recovery of gastrointestinal function compared to the control group. The time to first flatus was notably shorter in the early mobilization group ($P < 0.05$), indicating more rapid return of bowel function. This acceleration in gastrointestinal recovery can be attributed to the early oral intake and mobilization strategies implemented in the early mobilization protocol (Table 3).

Length of hospital stay

The early mobilization protocol resulted in a significant reduction in postoperative hospital stay. Patients in the early mobilization group had a mean length of stay of (8.2 ± 1.5) days, compared to (12.4 ± 2.3) days in the control group ($P < 0.05$). This reduction of approximately 4 days represents a substantial improvement in recovery time and hospital resource utilization (Table 4).

Table 3
Gastrointestinal function recovery.

Indicator	Early mobilization group ($n = 98$)	Late-stage mobilization group ($n = 122$)	Statistical value	*P*-value
Time to first bowel movement (hours)	72.1 ± 18.3	96.4 ± 20.5	0.25	<0.05
Time to first defecation (hours)	96.2 ± 22.4	120.5 ± 25.6	0.28	<0.05
Time to resume normal diet (hours)	48.0 ± 10.0	72.0 ± 12.0	0.30	<0.05
Nasogastric tube removal time (hours)	24.0 ± 5.0	48.0 ± 8.0	0.40	<0.001
Intra-abdominal drain removal time (hours)	36.0 ± 6.0	60.0 ± 10.0	0.38	<0.001
Early enteral feeding (hours)	24.0 ± 4.0	48.0 ± 6.0	0.42	<0.001
Postoperative nausea and vomiting (PONV) Rate (%)	20 (16.7%)	30 (25.0%)	0.15	0.21
Postoperative abdominal distension rate (%)	10 (8.3%)	25 (20.8%)	0.20	<0.05
Postoperative constipation rate (%)	15 (12.5%)	30 (25.0%)	0.22	<0.05
Postoperative diarrhea rate (%)	5 (4.2%)	10 (8.3%)	0.10	0.23

Table 4
Length of hospital stay and clinical recovery indicators.

Indicator	Early mobilization group ($n = 98$)	Late-stage mobilization group ($n = 122$)	Statistical value	*P*-value
Mean length of hospital stay (days)	8.2 ± 1.5	12.4 ± 2.3	0.30	<0.05
Median length of hospital stay (days)	8.0	12.0	0.28	<0.05
Postoperative complication rate (%)	25 (20.8%)	40 (33.3%)	0.25	<0.05
Readmission rate within 30 days (%)	5 (4.2%)	15 (12.5%)	0.20	<0.05
Postoperative infection rate (%)	10 (8.3%)	20 (16.7%)	0.22	<0.05
Patient satisfaction score (%)	85.0 ± 10.0	70.0 ± 12.0	0.40	<0.001
Postoperative pain score (VAS)	3.0 ± 1.0	4.5 ± 1.5	0.35	<0.05
Time to first ambulation (hours)	24.0 ± 6.0	48.0 ± 10.0	0.45	<0.001
Postoperative urinary retention rate (%)	5 (4.2%)	15 (12.5%)	0.20	<0.05
Postoperative pneumonia rate (%)	3 (2.5%)	10 (8.3%)	0.18	<0.05

Postoperative complications

The implementation of the early mobilization protocol was associated with a significantly lower incidence of postoperative complications. The overall complication rate within 30 days after surgery was 8.3% in the early mobilization group compared to 20.8% in the control group ($P < 0.05$). When classified according to the Clavien-Dindo system, the majority of complications in both groups were grade I-II, with fewer severe complications (grade III-IV) observed in the early mobilization group (Table 5).

Table 5
Postoperative complications.

Complication category	Early mobilization group ($n = 98$)	Late-stage mobilization group ($n = 122$)	Statistical value	*P*-value
Overall complication rate (%)	10 (8.3%)	25 (20.8%)	0.25	<0.05
Clavien-Dindo grade I-II complications (%)	8 (6.7%)	20 (16.7%)	0.22	<0.05
Clavien-Dindo grade III-IV complications (%)	2 (1.7%)	5 (4.2%)	0.18	<0.05
Postoperative infection (%)	3 (2.5%)	10 (8.3%)	0.20	<0.05
Postoperative hematoma (%)	1 (0.8%)	4 (3.3%)	0.15	<0.05
Postoperative pneumonia (%)	2 (1.7%)	8 (6.7%)	0.18	<0.05
Postoperative urinary retention (%)	2 (1.7%)	6 (5.0%)	0.16	<0.05
Postoperative constipation (%)	3 (2.5%)	10 (8.3%)	0.20	<0.05
Postoperative nausea and vomiting (PONV) (%)	2 (1.7%)	6 (5.0%)	0.16	<0.05

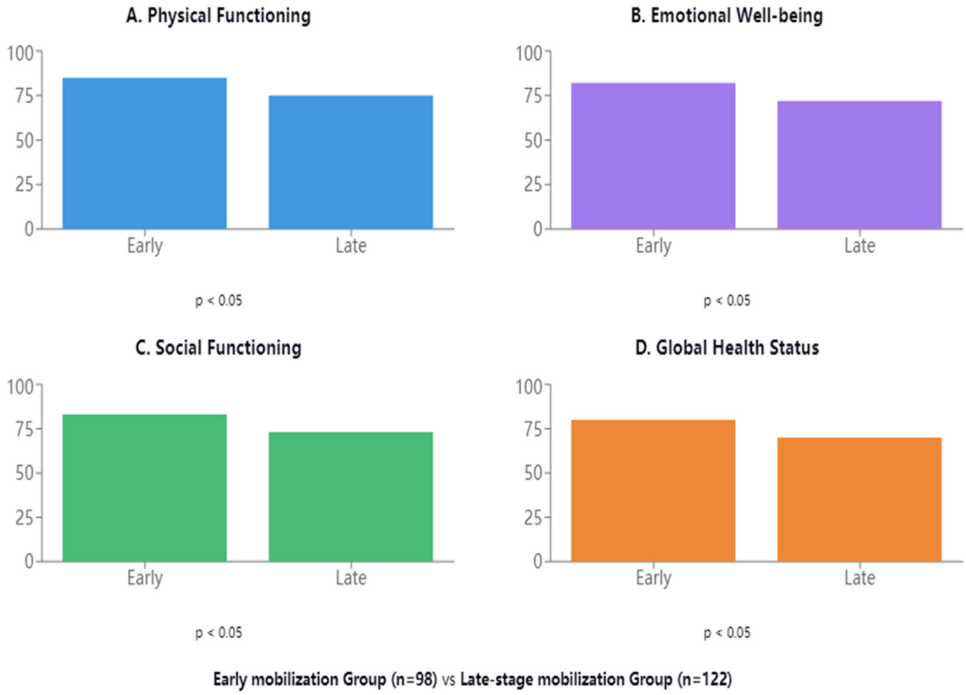

Fig. 2. Health outcomes after different mobilization approaches. (A) Physical functioning: Early mobilization patients demonstrate significantly better physical capabilities (85 vs 75 points), suggesting improved recovery of movement and daily activities. (B) Emotional Well-being: Patients mobilized early show markedly higher emotional health scores (82 vs 72 points), indicating better psychological adjustment and reduced distress. (C) Social Functioning: Early intervention leads to superior social engagement and relationship maintenance (83 vs 73 points), helping patients better maintain their social roles. (D) Global health status: Overall health perception is substantially higher in the early mobilization group (80 vs 70 points), reflecting better comprehensive recovery outcomes.

Quality of life assessment

Quality of life evaluation at 3 months postoperatively using the EORTC QLQ-C30 questionnaire demonstrated superior outcomes in the early mobilization group. Patients who received early mobilization care showed significantly higher scores in physical functioning, emotional well-being, and social functioning domains compared to the control group ($P < 0.05$). Global health status scores were also notably higher in the early mobilization group, indicating better overall recovery and rehabilitation (Fig 2A-D).

Multivariate analysis of risk factors for postoperative complications

To identify independent predictors of postoperative complications, multivariate logistic regression analysis was performed. Variables with $P < 0.1$ in univariate analysis were included in the multivariate model. The results showed that early mobilization protocol implementation was an independent protective factor against postoperative complications (OR = 0.32, 95% CI: 0.18-0.57, $P < 0.001$). Other significant independent risk factors included advanced age (>65 years) (OR = 2.45, 95% CI: 1.56-3.84, $P = 0.002$), higher ASA score (III vs I-II) (OR = 1.98, 95% CI: 1.24-3.16, $P = 0.004$), total gastrectomy (vs subtotal) (OR = 1.76, 95% CI: 1.15-2.69, $P = 0.009$), and prolonged operative time (>240 min) (OR = 1.85, 95% CI: 1.22-2.81, $P = 0.003$). Body mass index, tu-

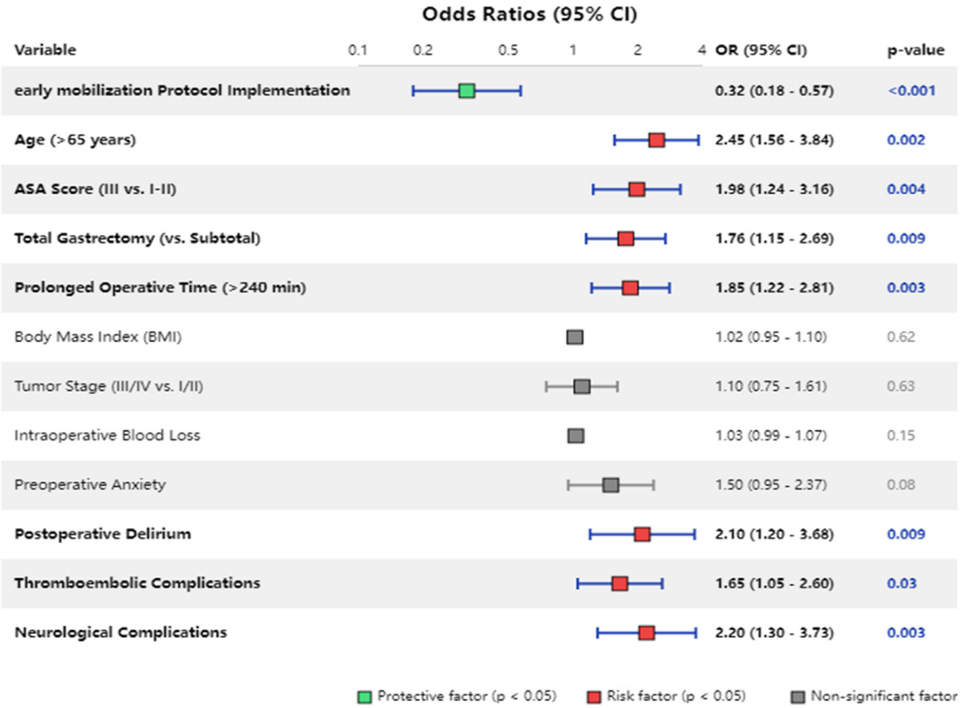

Fig. 3. A Crucial protective factor against postgastrectomy complications. The forest plot reveals early mobilization as the sole protective factor (OR 0.32, $P < 0.001$), reducing complications by 68%. Advanced age >65 (OR 2.45) and neurological complications (OR 2.20) present the highest risks, while factors like BMI and tumor stage showed no significant impact on outcomes.

mor stage, and intraoperative blood loss were not independently associated with postoperative complications in the multivariate analysis (all $P > 0.05$, Fig. 3).

Discussion

Gastric cancer, as one of the most common malignant tumors globally, has long been a focus of clinical attention regarding treatment efficacy and prognosis. Despite advancements in surgical techniques and perioperative management that have improved surgical safety in recent years, the incidence of postoperative complications remains high, with reported rates ranging from 15% to 30%.[17,18] Besides prolonging patient recovery time and increasing the medical burden, these complications may also influence the tumor prognosis in the long term. For advanced gastric cancer patients, the risk of postoperative complications is increased further as they undergo extensive surgical trauma and extensive lymph node dissection.[19-22]

Postoperative complications such as anastomotic leakage, pulmonary infections, incision infections, and intra-abdominal infections are common in gastric cancer patients. These complications may be related to several factors including age, nutritional status, comorbidities, and type of surgery. The conventional approach towards perioperative management primarily follows conservative strategies like extended fasting and disaster mobilization.[23-25] Although these strategies are motivated by safety, paradoxically they can lead to accentuated surgical stress responses, delayed recovery of organ function and increased complication rates. Thus, enhancing perioperative management to decrease the incidence of complications and improve the postoperative recovery of patients has emerged as a major area of current research.[11,26-28]

The early mobilization protocol significantly accelerated patients' postoperative gastrointestinal function recovery. Compared to the traditional treatment group, early mobilization group patients showed a notably shortened time to first flatulence ([48.3 ± 12.5]h vs [72.6 ± 15.8]h). This improvement may be attributed to the series of measures implemented in the early mobilization protocol, such as avoiding prolonged fasting, preoperative carbohydrate loading, and early enteral nutrition. These measures help maintain gastrointestinal function, reduce insulin resistance, and thereby promote postoperative recovery. This finding is consistent with previous research, with Zhang et al.'s study also demonstrating that the early mobilization protocol can significantly shorten gastric cancer patients' postoperative intestinal function recovery time.

The early mobilization protocol significantly reduced postoperative complication rates (8.3% vs 20.8%). Multivariate analysis revealed that early mobilization protocol implementation was an independent protective factor against postoperative complications (OR = 0.32, 95% CI: 0.18-0.57). This effect may result from the synergistic actions of multiple aspects of the early mobilization protocol, including standardized anesthesia protocols, goal-directed fluid management, and early mobilization. Notably, we found that advanced age (>65 years), higher ASA scores (Grade III), and prolonged surgical time (>240 minutes) were independent risk factors for postoperative complications. This suggests that more caution and individualization are required when implementing the early mobilization protocol for high-risk patients. Regarding hospital stay, early mobilization group patients demonstrated a significantly shortened average length of hospitalization ([8.2 ± 1.5]d vs [12.4 ± 2.3]d). This not only reduces medical costs but also decreases the risk of nosocomial infections and improves bed turnover rates. Importantly, the shortened hospital stay did not increase readmission rates, indicating that the early mobilization protocol enhances medical efficiency while ensuring patient safety.

Future research directions should include: (1) conducting multicenter randomized controlled trials to further validate the early mobilization protocol's effectiveness; (2) extending the follow-up period to assess long-term prognosis impacts; (3) exploring more individualized early mobilization protocols, especially for high-risk patient populations; (4) investigating the relative importance of each early mobilization component to optimize the protocol.

Limitations

Our study has several key limitations. Its retrospective design introduces potential selection bias despite propensity matching. Documentation quality varied across medical records. The nonblinded nature of the original care protocols likely affected subjective assessments. Retrospective quality of life measurements depended on patient recall. Being a single-center study at a specialized hospital limits generalizability. Our 30-day follow-up prevents evaluation of long-term outcomes, and cost analysis included only direct hospital expenses.

Conclusion

In conclusion, this study confirms the positive role of the early mobilization protocol in perioperative management of gastric cancer surgery. It not only facilitates patient postoperative recovery and reduces complication rates but also improves patient quality of life, demonstrating significant clinical application value. These findings provide robust evidence-based medical support for promoting early mobilization protocol application in gastric cancer surgery.

Author Contributions

Yaoyao Zhu: Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft. **Zhang Jing:** Data curation, Investigation, Visualization, Writing – original draft.

Xiaoxuan Chen: Methodology, Validation, Software, Writing – review & editing. **Limin Xia:** Supervision, Project administration, Writing – review & editing. **Chunxue Ma:** Supervision, Resources, Writing – review & editing. **Yaoyao Zhu and Zhang Jing:** contributed equally to this work. **Limin Xia and Chunxue Ma:** are co-corresponding authors.

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