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Role of Enhanced Recovery After Surgery (ERAS) Protocols in General Surgery

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ABSTRACT
Enhanced Recovery After Surgery (ERAS) protocols are designed to improve perioperative care by reducing surgical stress, accelerating functional recovery, and minimizing unnecessary hospitalization. This study evaluated the role of ERAS protocol adherence in elderly patients undergoing elective general surgery, with emphasis on compliance patterns, postoperative complications, and hospital utilization. The analysis included 188 patients managed within a standardized ERAS pathway. Compliance was assessed for early oral intake, early mobilization, suspension of intravenous fluids, urinary catheter removal, epidural anesthesia, drainage avoidance, and overall global adherence. Postoperative outcomes included Clavien-Dindo complications, ileus, anastomotic leakage, reoperation, mortality, hospital length of stay, and 30-day readmission. Global ERAS compliance was achieved in 56.0% of patients, while early oral intake and mobilization showed the highest adherence. Compliance was significantly lower among rectal surgery patients and those requiring stoma formation. Patients achieving global compliance had a shorter median hospital stay than those without full compliance. Differences in major complications, postoperative ileus, and anastomotic leakage were not statistically significant. Overall, ERAS adherence was most clearly associated with reduced hospitalization, supporting its value as a structured perioperative strategy in general and general surgical practice.

Keywords: Enhanced Recovery After Surgery; ERAS compliance; General surgery; Postoperative outcomes; Length of stay

1. Introduction

Enhanced Recovery After Surgery (ERAS) is a multimodal and multidisciplinary strategy to reduce surgical stress, maintain physiological function, optimize postoperative recovery and make the surgery more efficient. ERAS pathways are pathways based on evidence that involve interventions in the pre, intra and post-functioning period and do not rely on one intervention. In the initial consensus recommendations for general surgery, commonalities in the perioperative management of patients, including patient education, optimized nutrition, fluid management, analgesia, mobilization, and early feeding, were identified (Lassen et al., 2009).

The mechanisms of ERAS are physiologically related to the suppression of the neuroendocrine and inflammatory responses to surgical trauma, maintenance of metabolic homeostasis, and avoiding interventions which are not needed thereby delaying functional recovery (Scott et al., 2015). Meta-analytic evidence has proven that ERAS pathways have a positive impact on recovery after general surgery, especially on the reduction of hospital stay without a negative effect on patient safety (Lv et al, 2012). There are similar findings for patients undergoing major elective open general surgery, which further lend credence to the clinical benefits of multimodal recovery programmes (Varadhan et al., 2010).

The appropriate use of anesthetic and intraoperative management is also crucial to a successful ERAS program. There is consensus that multimodal analgesia, rational fluid therapy, avoidance of hypothermia, minimizing opioid exposure, and early restoration of normal function (Feldheiser et al. 2016) should be used. Thus, coordinated changes across multiple domains of perioperative practice are required to implement ERAS, not a single change in postoperative care. The integration of this poses an important challenge given that adherence to specific elements of the protocol could be affected by institutional resources, professional practices, patient characteristics, and surgical complexity (Hoffmann & Kettelhack, 2012).

The focus of enhanced recovery on early oral feeding, early mobilization, minimally invasive surgery and adequate pain management is well aligned with the principal factors influencing postsurgical recovery (Kelliher et al., 2015) and has been embraced into gastrointestinal surgery with greater frequency. Some of the same arguments have been used to advocate enhanced recovery pathways in major abdominal surgery to enhance clinical results and reduce unnecessary healthcare consumption (Miller et al., 2014). This is especially true of the expansion of ERAS to other surgical specialties, in which the movement from a traditional “one size fits all” perioperative care approach to a structured evidence-based pathway is gathering momentum (Melnyk et al., 2011).

The move toward improved recovery has also had an impact on the general surgical practice of postoperative care as a continuum of care from the time the patient is prepared for surgery to the time of discharge from the hospital (Evans and Kennedy, 2011). Previous systematic research in colonic surgery indicated that enhanced recovery programs could lead to reduced hospital stay after surgery and aid in the earlier restoration of normal functions as compared to conventional surgery pathways (Wind et al., 2006). Additional randomized evidence further supported the need for ERAS implementation in general surgery (Eskicioglu et al., 2009).

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Importantly, the successful implementation cannot be assessed only on the presence of an ERAS protocol. The effectiveness of clinical outcomes may depend on the extent of implementation of individual interventions. Systematic use of evidence-based peri-operative components and compliance monitoring are therefore formalized recommendations of the ERAS Society (Gustafsson et al., 2013).

Therefore, the persistence of the current study was to estimate the effects of ERAS protocol application in general surgical practice, with a focus on the elderly population undergoing elective general surgery. The scope encompassed characterization of surgical procedures, compliance with individual ERAS interventions, compliance with global ERAS, comparison of compliance in surgical subgroups and assessment of postoperative difficulties, length of hospital stay, reoperation, mortality and readmission. The main goal was to assess whether fulfillment with ERAS principles was correlated with better postoperative recovery and health-care utilization results.

2. Methodology

2.1 Study Design, Population, and Analytical Scope

Previously collected prospective clinical data were analyzed in a secondary analysis to assess adherence ERAS intervention and results following elective general surgery in older adults. 188 consecutive patients who were at least 70 years old and underwent elective colon or rectal resection between 2013 and 2014 in 3 tertiary university hospitals. Urgent and palliative surgery were not included. All patients included were treated in an ERAS pathway (Gonzalez-Ayora et al., 2016). Only variables and numerical results that were explicitly provided in the source material were included in the present analysis. Thus, the denominator used for the percentages for overall demographic, surgical, ERAS-compliance, and postoperative-outcome data was N = 188, except when the denominator was a procedure-specific subgroup. There were 145 patients with colon surgery and 43 patients with rectal surgery. sigmoidoscopy, low anterior resection, Hartmann's technique, right and left colectomy, and abdominoperineal resection were surgical procedures performed. Surgical features included laparoscopy approach and temporary or definitive stoma formation. No reconstruction or simulation of individual patient record was performed as only aggregated data were available for the present secondary analysis. All analyses and tables, therefore, reflect the counts and percentages as originally reported, as well as medians, ranges, comparisons among subgroups, and probability values.

2.2 Variables and Operational Definitions

Baseline characteristics were age, sex, diabetes, anticoagulant treatment, and Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity (POSSUM). The age and POSSUM morbidity/mortality estimates were treated as continuous variables and the median and range reported. The following factors were treated as categorical variables: sex, diabetes, anticoagulant therapy, surgical site, surgical approach, and formation of the stoma. Expected postoperative morbidity and mortality was used as an indicator using POSSUM.

Exposure to ERAS was assessed by compliance with each of the perioperative interventions. The pathway included: preoperative counselling and nutritional assessment; avoiding full mechanical bowel preparation for colon surgery; evading nasogastric tubes and drains when feasible; early oral intake; early mobilization; early intravenous fluid cessation; early urine catheter removal; and multimodal analgesia. Giving oral fluids six to eight hours after surgery is known as early postoperative oral intake, and getting out of bed and moving around at six to eight hours is known as early mobilization. Early IV fluid withdrawal and urinary catheter removal to completion by the first day after surgery.

The ERAS indicators available quantitatively for the Results analysis were: no drainage, epidural anesthesia, early intake, early mobilization, early urine catheter removal, early termination of intravenous fluids, and worldwide compliance. Global compliance defined as meeting all ERAS measures in the global-compliance assessment. The denominator for overall global compliance was the entire cohort (188 patients, 105 (56.0%) of which met global-compliance definition). Drainage and epidural anesthesia, with no reports given separately, were not included in the calculation of global compliance.

Global ERAS compliance was further analyzed based on laparoscopy versus open surgery, colon versus rectal surgery, and no stoma versus stoma. Percentages in these comparisons are based on the number of patients meeting global compliance in the designated surgical subgroups, not the total number of patients.

Postoperative outcomes included absence of complications, postoperative ileus, anastomotic leakage, reoperation, mortality, hospital length of stay (LOS), 30-day hospital readmission, and minor (Clavien-Dindo grades I–II) and substantial (Clavien-Dindo grades III–V) problems. Global-compliance was used as the grouping variable for complication comparisons. Hospital LOS was reported as median and range and included days of readmission, if applicable.

2.3 ERAS Compliance and Postoperative Outcome Assessment

The compliance with every ERAS intervention was evaluated by analyzing the clinical documentation in the inpatient setting. The percentage of compliance with individual interventions was displayed, as well as the number of times the intervention was used. Global compliance was complete adherence to any measures included in the global-compliance definition. These two classifications were used as the basis for the major comparisons of the results following surgery reported in the Results.

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Two outcomes were used to assess the relationship between ERAS adherence and clinical recovery: postoperative complications and hospital LOS. Complication rates were calculated as percentage of the appropriate compliance groups. In particular, the reported analyses compared the groups of patients who complied with global standards for minor Clavien-Dindo complications, major Clavien-Dindo complications, postoperative ileus and anastomotic leakage. The compliance-specific estimates of reoperation, mortality, and 30-day readmission were not reported and therefore could not be estimated or imputed.

LOS at the hospital was measured as a recovery outcome. The discharge plan was a postoperative day 4 for colon surgery and 5 for rectal surgery, based on adequate mobilization, oral intake, gastrointestinal recovery, urinary function, wound status, pain control, lack of recent fever, acceptable C-reactive protein level and readiness of patient and family for discharge.

2.4 Statistical Analysis

While continuous variables were displayed, categorical variables were displayed in frequency and percentage format in a summary format in line with the data available. Age, POSSUM scores and hospital LOS was thus reported as Median (range).

Comparisons of unconditional proportions were carried out using the chi-square test, using Fisher's exact test if an expected cell frequency was less than 5. This approach would be applicable to the reported comparisons of global compliance based on laparoscopic versus open surgery, colon versus rectal, stoma status, and comparisons of proportions of complications between patients with versus without global ERAS compliance.

The original analytical plan called for analysis of variance for continuous measurements with a normal distribution and the Mann-Whitney test for continuous measures with a non-normal distribution. Compliance-group comparisons of LOS were examined as non-parametric since LOS was reported as median and range. According to the paper, this Kruskal-Wallis test was used to examine the connection between the hospital LOS and the level of ERAS compliance. Statistical significance was defined as a p value of less than 0.05.

Regression models weren't fitted or reported. Instead, logistic regression, linear regression, Cox regression, adjusted odds ratios, regression coefficients, patient-level confidence intervals from regression models and multivariable adjustment were not introduced as these are valid only with available individual-level data.

2.5 Missing Data and Ethical Considerations

Information on ERAS compliance was collected from the inpatient medical records. When documentation for an ERAS intervention was missing, it was considered non-compliant. Hence, the missing value category “incomplete documentation” was not considered as such and was not used for statistical imputation.

No other missing-value rate was reported for demographic, surgical or postoperative variables used in the Results. Thus, it was assumed that all data at the patient level would not be used except what was published. No mean substitution, multiple imputations, case wise reconstruction, synthetic patients or interpolation was conducted. If there was no denominator or patient-level value available in the aggregate data, then a new denominator or patient-level value was not generated.

The multi-center study was approved by the local institutional review board at each institution. The present work is a secondary analysis of previously published aggregated and de-identified information and did not require the recruitment, intervention or additional collection of identifiable patient clinical information from any patients.

3. Results

3.1 Patient Characteristics and Surgical Profile

A total of 188 patients were comprised in the study. The proportion of males (58.0%) to females (42.0%) in the cohort. Twenty-eight patients (28.0%) had diabetes and 19 (19.0%) were under anticoagulant therapy. The median morbidity and mortality scores were 29.3% and 5.3% respectively. The majority of patients had colon surgery (77.1%) and the remainder had rectal surgery (22.9%). Overall, 44.1% of the procedures were performed laparoscopically. As shown in Table 1 and Figure 1, the most common specific operation was right colectomy and sigmoidoscopy and low anterior resection were the second and third most common operations respectively.

Table 1. Baseline and Surgical Characteristics of the Study Population

Characteristic	Value	Percentage/Range
Total patients	188	100%
Age, median	79 years	70-93 years
Male	109	58.0%
Female	79	42.0%
Diabetes	52	28.0%

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Characteristic	Value	Percentage/Range
Anticoagulant treatment	36	19.0%
POSSUM morbidity score, median	29.3%	6.9-80.5%
POSSUM mortality score, median	5.3%	1.3-26.8%
Colon surgery	145	77.1%
Rectal surgery	43	22.9%
Total laparoscopic surgery	83	44.1%
Right colectomy	80	42.6%
Left colectomy	15	8.0%
Sigmoidectomy	50	26.6%
Low anterior resection	34	18.1%
Hartmann procedure	7	3.7%
Abdominoperineal resection	2	1.1%
Stoma formation	25	13.3%

As shown in Figure 1, right colectomy constituted the largest proportion of procedures at 42.6%, followed by sigmoidectomy at 26.6% and low anterior resection at 18.1%. Less frequent procedures included left colectomy, Hartmann procedure, and abdominoperineal resection.

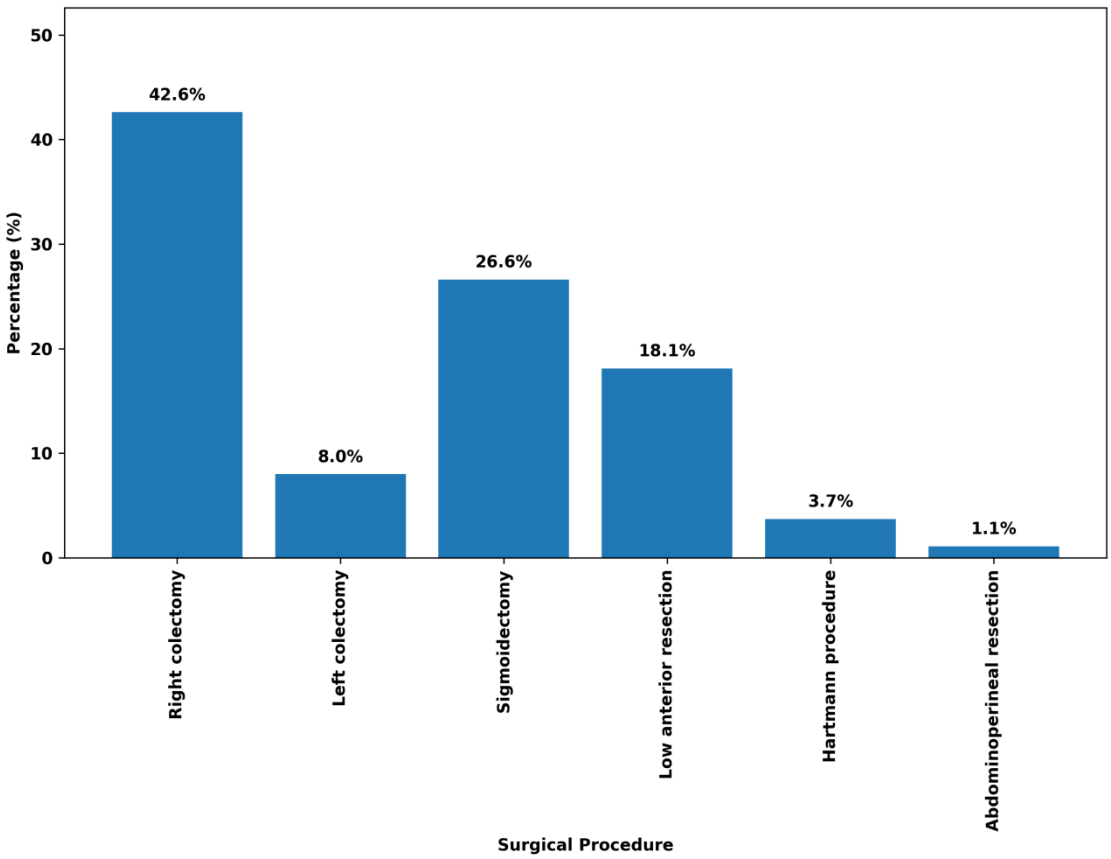

Figure 1: Distribution of surgical procedures among patients managed within the ERAS pathway

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3.2 Compliance with ERAS Interventions

There was a wide range of compliance for individual ERAS interventions. Early oral intake (92.0%) and early mobilization (89.9%) had the most favorable adherence rate. The early removal of the intravenous fluids was successful in 73.4% of patients, while that of the urinary catheter was successful in 64.9%. Sixty-one per cent received epidural anaesthesia and 43 per cent of patients avoided the use of a drainage. In total, 105 patients made 56.0% of the study population compliant with global ERAS. The adherence distribution by main components of ERAS is shown in Table 2 and Figure 2.

Table 2. Compliance With Individual ERAS Interventions

ERAS Intervention	Patients (n)	Compliance (%)
No drainage	81	43.0
Epidural anesthesia	116	61.7
Early intake	173	92.0
Early suspension of IV fluids	138	73.4
Early mobilization	169	89.9
Early urinary catheter removal	122	64.9
Global ERAS compliance	105	56.0

As demonstrated in Figure 2, early intake and early organisation showed the greatest adherence, whereas avoidance of drainage demonstrated the lowest compliance. This indicates that implementation success varied substantially among the different ERAS components.

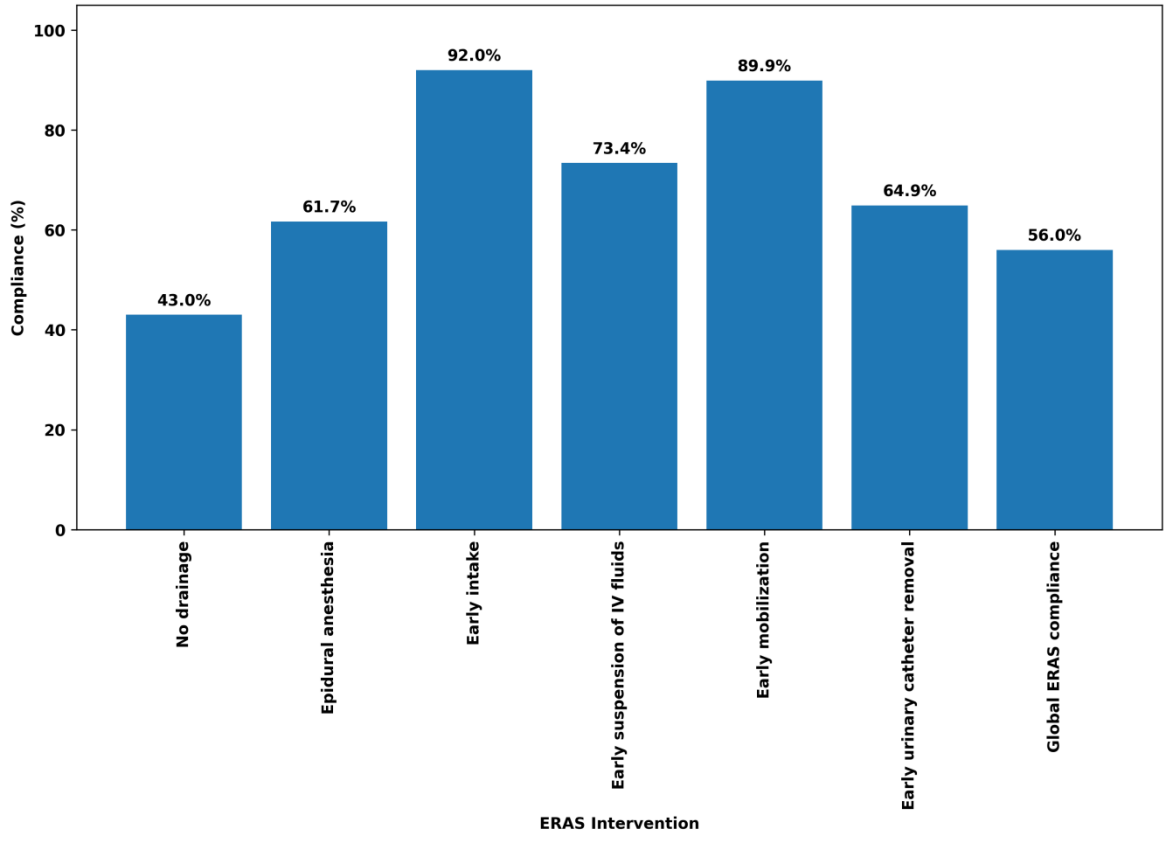

Figure 2: Compliance rates for individual ERAS interventions and overall global compliance

3.3 Global ERAS Compliance Across Surgical Subgroups

The compliance with ERAS was variable at global level depending on the type and complexity of surgery. Higher compliance was seen in laparoscopic procedures than in open procedures (59.0% vs. 53.3%, respectively), although

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there was no statistically significant differentiation (p = 0.43). The differences were marked by region of surgery and/or stoma. Patients who had colon surgery had global compliance of 60.0%, compared with 41.9% of those who had rectal surgery (p = 0.03). Likewise, patients without a stoma were much more compliant than those with a stoma (58.9% versus 36.0%, p = 0.03). The summarised comparisons can be seen in Table 3 and in Figure 3.

Table 3. Global ERAS Compliance According to Surgical Characteristics

Comparison	Global Compliance (%)	p-value	Interpretation
Open surgery	53.3		
Without stoma	58.9	0.03	Significant
With stoma	36.0		

As illustrated in Figure 3, the highest global ERAS compliance was recorded among colon surgery patients, whereas the lowest rate occurred among patients with a stoma. The findings suggest that more complex surgical situations, particularly rectal procedures and stoma construction, were associated with greater difficulty in achieving complete ERAS adherence.

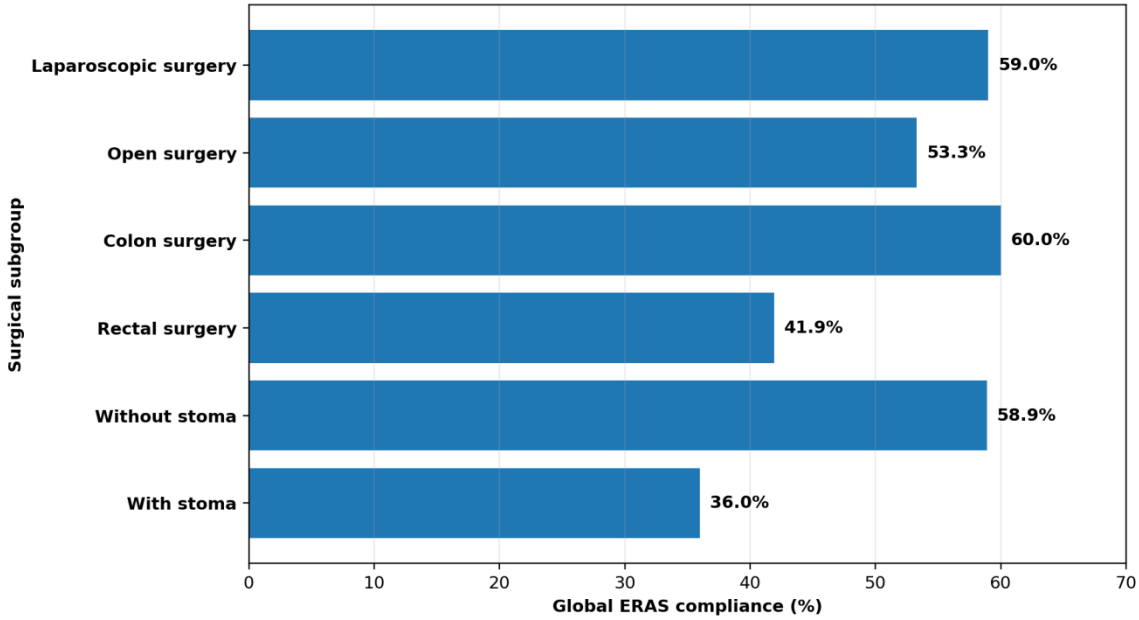

Figure 3: Global ERAS compliance according to laparoscopic/open surgery, colon/rectal surgery, and stoma status

3.4 Postoperative Outcomes According to ERAS Compliance

Overall, 62.2% of patients did not have any postoperative complications. There were 24.5% of minor (grade I-II) complications and 13.3% of major (grade III-V) complications reported. Twenty-three (23.4%) patients had postoperative ileus and 8.0% patients had anastomotic leakage. Reoperation was required in 8.5% while postoperative mortality was 1.6%. There were mixed results when comparing by global ERAS compliance. Minor complications were found in 30.0% of the patients who were compliant globally, and 20.0% of the patients who were not compliant globally, but this was not statistically important (p = 0.32). The major complication rates were almost equal (13.4% vs 13.2%, p = 0.34). However, globally compliant patients had a lower number of cases of postoperative ileus (21.0%) than non-compliant patients (26.5%) (numerically). Patients that were compliant with the treatment also had slightly less anastomotic leakage (7.6% compared to 8.4%). Both contrasts were not statistically significant. The results are summarized in the table below (Table 4) and a comparison of the postoperative outcome profile is shown in the figure below (Figure 4).

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Table 4. Postoperative Outcomes and Hospital Utilization

Outcome	Overall Result	With Global Compliance	Without Global Compliance	p-value
No complications	117 (62.2%)	-	-	-
Clavien-Dindo I-II	46 (24.5%)	30.0%	20.0%	0.32
Clavien-Dindo III-V	25 (13.3%)	13.4%	13.2%	0.34
Postoperative ileus	44 (23.4%)	21.0%	26.5%	0.37
Anastomotic leakage	15 (8.0%)	7.6%	8.4%	0.83
Reoperation	16 (8.5%)	-	-	-
Mortality	3 (1.6%)	-	-	-
Median hospital stay	6 days	6 days	7 days	0.03
30-day readmission	12 (6.4%)	-	-	-

As shown in Figure 4, complete ERAS compliance was associated with numerically lower postoperative ileus and anastomotic leakage, whereas major complications were almost identical between groups. Minor complications were numerically higher in the globally compliant group, although the reported difference was not significant.

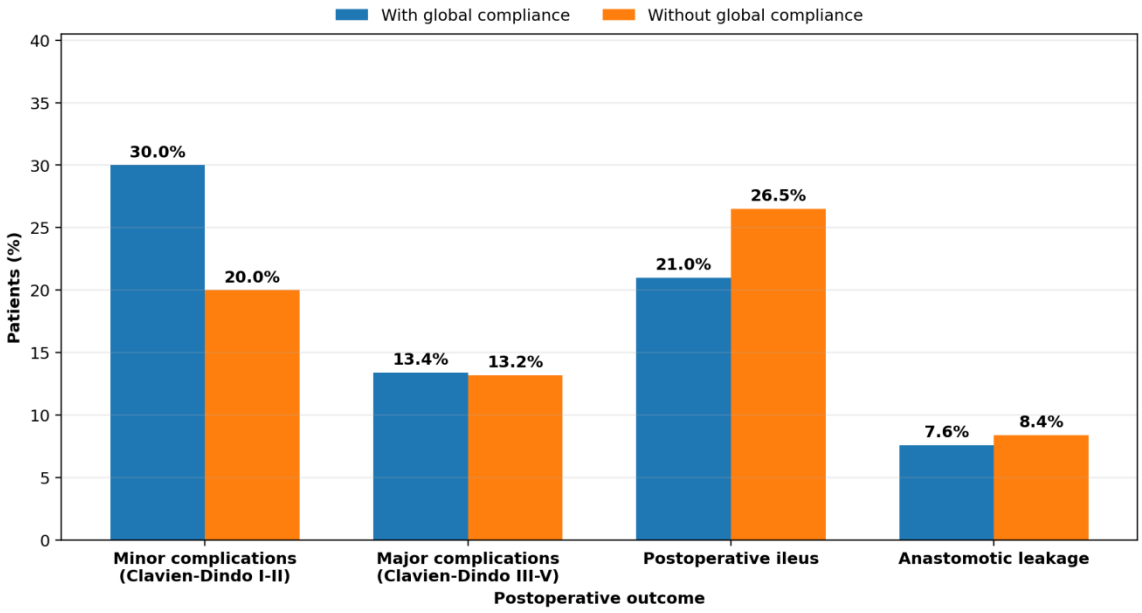

Figure 4: Comparison of postoperative complication rates between patients with and without global ERAS compliance

3.5 Length of Stay, Reoperation, and Readmission

Hospital stays varied from 3 to 51 days, with an average of 6 days. There was a strong correlation with global ERAS compliance and the reduction in hospital stay. Median residence time was 6 days for patients with global compliance vs 7 days for patients without, $p = 0.03$. If compliance was considered based on a threshold of 50% or more, patients with less than 50% compliance had a median hospital stay of 7.5 days, compared with 6 days for the patients who achieved at least 50% compliance; this comparison was statistically significant ($p < 0.04$) according to the source analysis. Overall, 16 patients (8.5%) underwent reoperation, mainly due to the anastomotic leakage. 12 (6.4%) patients were readmitted within 30 days. Dehydration, late anastomotic leakage, wound infection, and abdominal abscess were reported as

causes. Overall these findings suggest the most consistent measurable improvement as a result of ERAS adherence in this dataset was a reduction in hospital span of stay, with the results showing varying measures of individual postoperative complications being generally small and not statistically significant.

4. Discussion

The current results show that ERAS is possible in elderly general surgery patients, but the implementation of the individual components varied greatly and surgical subgroups experienced varying compliance. The overall compliance was 56.0% and early oral intake and early mobilization had the highest compliance of 92.0% and 89.9% respectively. This is clinically relevant since other studies have demonstrated that enhanced effectiveness of ERAS pathways is tied to better results following general cancer surgery (Gustafsson et al., 2011).

The most obvious outcome of ERAS compliance in the current analysis was hospital interval of stay. The median LOS was 6 days for those who were globally compliant, and 7 days for those who were not, which was statistically significant. This is consistent with previous reports that ERAS pathways can shorten recovery time after a general surgery compared to a standard general postoperative pathway (Teeuwen et al, 2010). Structured ERAS programs have also been shown to be both feasible and capable of decreasing hospital stay, when implemented in community general practice (Geltzeiler et al., 2014).

The current findings are also in line with reports of the beneficial effect of ERAS on several aspects of postoperative recovery, such as hospital length of stay, pain management, bowel function and urinary recovery (Sarin et al., 2015). The strong uptake of early intake and mobilization here indicates that these interventions could be some of the most easily adopted components of recovery pathways. The implementation studies in institutions have also demonstrated that adopting the ERAS principles in general surgery is possible (Bona et al., 2014).

Although there was an improvement in LOS, there was no association with overall compliance and a statistically significant decrease in individual postoperative complications. The difference was not significant, with postoperative ileus being lower in globally compliant patients (21.0%) than in non-compliant patients (26.5%). Previous studies on enhanced recovery, however, have shown that improved functional recovery without increased adverse clinical outcomes is possible (Abraham & Albayati, 2011). Standardized ERAS pathways have also been shown in prospective general studies to be generally safe and feasible (Fierens et al., 2012).

However, the lack of significant differences in major complications should not be considered as proof of lack of clinical value of ERAS. Measures of outcomes reported beyond morbidity include recovery, functional restoration, hospitalization, readmission and patient-centered outcomes (Feldman et al., 2015). There has also been a focus in the literature on the importance of looking at the efficacy of ERAS in a multi-endpoint fashion instead of a single endpoint measure that is a complication (Mwanga, 2016).

There was wide variation between surgical characteristics for global compliance. Compliance was higher in colon surgery compared to that in rectal surgery, and patients without a stoma showed significantly greater compliance than patients who needed a stoma to be created. These results suggest that the complexity of the procedure could affect the completion of all ERAS elements. The experience gained from emergency general surgery further indicates that ERAS principles can be applied successfully, but with the consideration of some differences in clinical contexts and the severity of the surgery (Lohsiriwat, 2014a).

Patient related factors are also potential influencers of recovery and ERAS success. Appropriate preoperative assessment and optimization, such as nutritional status, has been correlated with outcomes among general cancer patients within ERAS programs, highlighting the importance of optimizing nutritional status (Lohsiriwat, 2014b). Enhanced recovery principles have been applied to populations of larger complexity, such as penetrating abdominal trauma (Moydien et al., 2016), which further support their feasibility in more complex general-surgical populations.

The overall rates of readmission (6.4%), reoperation (8.5%) and mortality (1.6%) suggest that there was no clear demonstrate of an enhanced risk of adverse utilization outcomes as a result of shortened recovery pathways. This should therefore be thought of as an overall shift in peri-operative care and practice, and not just an early-discharge initiative (Steenhagen, 2016). Multidisciplinary coordination and patient education will also continue to be important for maintaining adherence to the protocol during the recovery pathways of the general cancer process (Burch, 2013).

In summary, the results are favorable to implementing ERAS in general surgery and, especially, in relation to shorter hospital stays. But the small sample size, lack of a conventional care control group, the fact that the available data was aggregated, and the absence of patient-level multivariable models make it difficult to interpret the results as causal. Larger controlled cohorts and patient-level analysis should be adjusted to explore the individual ERAS components and overall, ERAS adherence in future prospective studies.

5. Conclusion

This study illustrates how the implementation of ERAS protocol can be done in safety for the elderly population in elective general surgery and how it can help to enhance postoperative recovery. Overall, ERAS compliance was achieved in just over half of the study population, with compliance being highest for early oral intake and early mobilization. Importantly, the patients who were not compliant with ERAS had a noticeably lengthier hospital stay; the median hospital stay for patients who complied with ERAS worldwide was six days, compared to seven days for

patients who did not. Readmission, reoperation, and mortality rates were comparatively low and showed no discernible differences between the ERAS and non-ERAS groups. indicating the feasibility and safety of the ERAS approach. There were lower compliance rates in rectal surgery patients and those needing stoma formation, suggesting that surgical complexity may affect successful protocol implementation. The overall results indicate that ERAS is an organized perioperative approach in general surgery and general surgery that is beneficial in terms of reduction the hospital stay and facilitating recovery. It is necessary to have larger patient-level datasets and controlled comparative designs to better elucidate each of the independent effects of the ERAS components on postoperative outcomes.

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