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Assessment of the Efficacy and Safety of Enhanced Recovery After Surgery (ERAS) Protocols in Patients Undergoing Bariatric Surgery: A Meta-Analysis

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ABSTRACT

In modern era bariatric surgeries, the use of several tools of the Enhanced Recovery after Surgery (ERAS) protocols are highly accepted and associated with reduced peri-operative rate of complications and robust recovery. **Objectives:** To evaluate the impact of application of ERAS protocols in bariatric surgeries, with relevance to postoperative recovery period, postsurgical complications, length of hospital stay and cost effectiveness. **Methods:** Various randomized controlled trials (RCTs), reviews and observational studies implementing ERAS protocols in bariatric surgeries were included in this meta-analysis after performing a comprehensive search over databases up to August 2024. **Results:** This meta-analysis affirmed that ERAS protocols significantly reduced the post-operative length of hospitalization by an average of 1.5 days, reduced opioid consumption by approximately 30.7%, and also led to a decreased incidence of major complications (mean 4.16%). The readmission rates remained low (mean 4.16%) in the ERAS group, and overall complication rates were also reduced in studies implementing an increased number of ERAS protocol elements.Subgroup analysis revealed that Sleeve Gastrectomy (SG) was associated with shorter recovery period and fewer complications when compared to Roux-en-Y Gastric Bypass (RYGB). **Conclusions:** It was concluded that this meta-analysis favors the implementation of ERAS principles in improving outcomes in bariatric surgeries, including shorter hospital stays, reduced recovery period, less need of opioid analgesia and increased patient satisfaction.

INTRODUCTION

Enhanced Recovery After Surgery (ERAS) protocols have revolutionized perioperative care in bariatric surgery by the implementation of multimodal strategies to optimize patient outcomes, reduce complications and surgical stress associated with bariatric surgery [1]. This meta-analysis aims to assess the efficacy and safety of ERAS protocols in patients undergoing bariatric surgery by evaluating postoperative outcomes, complication rates, and recovery. Bariatric surgery (BS) is a trending treatment choice for people who suffer from severe morbid obesity (BMI greater than 35kg/m2) associated with major comorbid conditions, in whom other non-surgical weight loss measures have failed to give fruitful results [1]. Bariatric surgery has not only had a direct impact on weight loss, but also improves overall quality of life and several other health parameters, including metabolic syndrome [2]. On the other hand, such procedures are difficult because often patients have complex medical histories and metabolic syndromes, which increase perioperative risks, and thus there is a crucial need to optimize perioperative care to enhance patient outcomes [3]. Hence, the application of Enhanced Recovery after

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Surgery (ERAS) principles is particularly relevant. The ERAS protocol is a multidisciplinary approach, has shown promising results in reducing hospital stays, postoperative complications and enhancing recovery in various surgical specialties, thus making it an area of significant clinical interest[4].

Despite growing adoption of Enhanced Recovery After Surgery (ERAS) protocols in bariatric surgery, significant variability remains in protocol components, adherence levels, and reported clinical outcomes across different studies and healthcare settings. Existing evidence demonstrates benefits such as reduced hospital stay, lower opioid use, and fewer complications, but inconsistencies in study design, patient populations, and surgical procedures limit the ability to establish standardized bariatric-specific ERAS guidelines. The major research gap lies in the lack of high-quality, uniformly designed large-scale randomized controlled trials that clearly identify the most effective ERAS components for different bariatric procedures. Therefore, this meta-analysis aimed to comprehensively evaluate the efficacy and safety of ERAS protocols in bariatric surgery by assessing recovery outcomes, complication rates, hospitalization duration, and opioid reduction while identifying areas requiring protocol standardization. This study aimed to utilize evidence from various studies to evaluate the impact of ERAS protocols on perioperative outcomes in bariatric surgery, thus providing a comprehensive assessment of its efficacy and safety. By utilizing the data available, we can also identify areas where further improvement is needed and whether ERAS protocols can be considered a standard of care in other surgical specialties as well, besides bariatric surgery.

METHODS

This meta-analysis was conducted and reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [5]. Various randomized controlled trials (RCTs), reviews and observational studies comparing ERAS protocols with standard care (SC) in bariatric surgeries were included in our meta-analysis after performing a comprehensive search over databases like PubMed, Cochrane Library, Google Scholar and Web of Science, up to August 2024. The search strategy combined both Medical Subject Headings and free-text terms. The search was conducted in English language and the main keywords used in our search were "Enhanced Recovery After Surgery" or "ERAS", "Weight loss or Metabolic surgery" or "Bariatric Surgery", "Roux-en-Y Gastric Bypass" or "Sleeve Gastrectomy", "Perioperative Care", "Duration of Hospital Stay" or "Peri- and Post-Operative Complications." Only studies published in the English language were included. Duration of hospital stay was the primary outcome measured across studies included in our analysis, and secondary outcomes were overall morbidity and peri-operative and post-operative complication rates (bleeding, leakage, infection, cardiopulmonary), mortality rates and readmissions. Three researchers (JMA, IM and AA) independently carried out the process of selection of studies. The selection was then compared, and any discrepancy, if found, was settled by mutual discussion. The first 3 authors independently determined the eligibility of the relevant articles, and included studies evaluating ERAS protocols in patients undergoing bariatric surgery (Sleeve Gastrectomy SG, Roux-en-Y Gastric Bypass RYGB or both). Randomized controlled trials, case-control studies, cohort studies and observational studies comparing ERAS and Standard Care in bariatric surgery were included. Only studies published in English were considered. Studies conducted in different geographic regions were included to assess the generalizability of ERAS protocols, and also with clearly defined methodology and outcome measures to minimize reporting bias. Studies reporting perioperative outcomes like duration of hospital stay, post-operative complications, readmissions, and mortality rates were also included. Only the latest and highly comprehensive data were included. Reviews, editorials, abstracts, and case reports were not included in this meta-analysis. Non-comparative studies, i.e., ERAS vs. standard care and studies on other surgical specialties without specific reference to bariatric surgery, were not added. Animal and in vitro studies and those without a clear description of ERAS principles were also excluded. Studies that failed to distinguish between ERAS and conventional perioperative care were not included. A careful review of all the eligible full-text articles was done before adding them to the meta-analysis, and data extraction was based on pre-defined criteria. The abstracts, methodology and results were independently screened by two reviewers. Data extraction was done in tabulated form highlighting study demographics i.e., authors, country, study design, sample size, follow-up period; patients baseline demographics i.e., gender, age, BMI, type of surgery and comorbidity; clinical outcome indicators like duration of hospital stay, post-operative complications, readmission, cost of hospitalization, mortality rates and ERAS protocol principles. A comprehensive, structured approach was ensured to carry out a robust meta-analysis report on the efficacy and safety of ERAS in bariatric surgery patients. The random effects model was used to assess for variability across various studies, reflecting the differences in sample sizes, study designs and populations. This model is appropriate while dealing with heterogeneous studies, as it assumes that individual studies estimate variable but related treatment effects. This provided a more generalized interpretation of the results. In cases where the population of interest constituted a subset of the study population, only the

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readings or values about the population of interest were selected. If the extraction of the values of the population of interest was not possible, then the study was excluded from the meta-analysis. The data extraction records us maintained with the authors and will be used to refer back to the process of data extraction if needed. This meta-analysis used descriptive statistics to find out the impact of ERAS protocols and the Standard Care group on surgical outcomes (Fisher's exact test). The continuous outcomes, e.g., duration of hospital stay, mean differences (MD) or standardized mean differences (SMD) were calculated, with data pooled utilizing a random effects model to account for variability among included studies. The dichotomous outcomes, i.e., post-operative complications, odds ratios (OR) or relative risks with 95% confidence intervals, were calculated and pooled using a random-effects model. Results were carefully interpreted while considering both statistical significance ($p<0.05$) and clinical relevance, with reliability of conclusions assessed by sensitivity analyses and consideration of potential biases. Statistical heterogeneity was evaluated by using the I^2 statistics, which determines the percentage of variability due to heterogeneity rather than chance. It is crucial to identify heterogeneity in meta-analysis as it determines the confidence in the pooled results. Sensitivity analyses were carried out to determine the resilience of the obtained results. These analyses assessed the influence of excluding studies with high risk of bias, as well as the impact of varying methodological quality across the studies included in ours. Studies were not included that seemed methodologically weak, and the consistency of overall outcomes was determined, ensuring the reliability of the pooled estimates. The statistical analysis was conducted using the Rev-Man software tool, a standard tool for meta-analyses. The risk of bias from missing results was assessed by several methods, which include: The Forest plots tool was used to identify publication bias by plotting effect sizes against their standard errors, and Egger's test was carried out to statistically assess the overall symmetry of the plot. The initial literature search yielded 380 citations; 325 remained after the exclusion of duplicate publications; 21 studies were eventually included after meeting the pre-defined inclusion criteria of our meta-analysis (Figure 1).

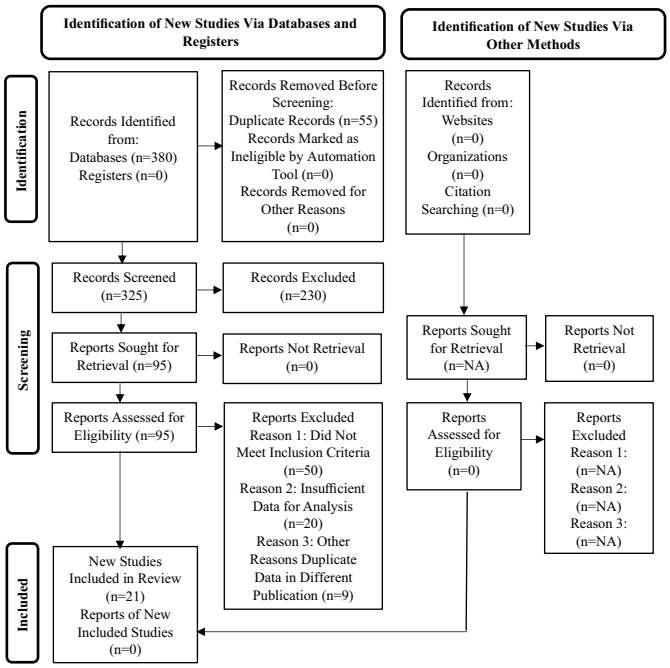

Figure 1: Study Selection for This Research

RESULTS

A total of 21 studies met the inclusion criteria of our meta-analysis, and it includes a vast range of study designs, including randomized controlled trials (RCTs), cohort studies, retrospective studies and systematic reviews. The studies included in our meta-analysis involve a significant number of patients undergoing various bariatric surgical procedures, i.e., SG and RYSG, and thus allow a comprehensive analysis of the ERAS principle's impact on post-operative outcome. A substantial total sample size of 9899 patients was included in our analyses. The largest sample size was seen in the study by Małczak *et al.*, [6] i.e., 3475 patients and the smallest in Schmoke *et al.*, [7] with only 21 patients in the ERAS group. A study by Stenberg *et al.* [8] met the inclusion criteria, but it was excluded after reviewing because the quality of evidence for many ERAS elements remains relatively low, especially in the context of bariatric surgery. Many recommendations are based on evidence assumed from other types of surgeries rather than bariatric-specific studies. A broad range of bariatric surgeries, i.e., laparoscopic sleeve gastrectomy and Roux-en-Y gastric bypass, and randomized controlled trials, retrospective cohort studies and observational studies were included in our paper, which enhances the generalizability of our meta-analysis findings. Our meta-analysis included studies up to August 2024, which is important for analyzing current era practices and patient outcomes (Table 1).

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Table 1: Characteristics of Studies Included

References	Country	Study Design	Patients Number	Gender (M/F)	Age (Years)	BMI (Kg/m^2)	Follow-up (days)	Type of Surgery	ERAS Adherence
[9]	Brazil	Cross-sectional	150	41/109	37	41.9	30	SG	Full
[10]	Luxembourg	RCS	103	26/77	42.1 ± 11.84	44.8 ± 5.9	30	RYGB	Partial
[11]	Not Specified	RCT	374	Not Specified	Not Specified	Not Specified	Not Specified	Mixed	Full
[12]	Netherlands	RCT	110	12/98	42.7 ± 10.5	42	30	SG	Full
[13]	United States	Review	435	Not Specified	Not Specified	Not Specified	Not Specified	SG	Full
[6]	Poland	Review	3475	Not specified	Not specified	Not specified	Not specified	Mixed	Full
[14]	USA	RCS	134	11/123	44	44	30	RYGB	Full
[15]	UAE	RCS	1602	572/1030	30.41	43.95 ± 5.60	30	SG	Full
[16]	India	RCT	56	14/42	36.21	42.33 ± 7.01	30	SG	Full
[17]	China	RCS	237	58/179	32.61	38.38 ± 6.78	30	RYGB	Full
[18]	United States	Retrospective	657	77.6% Female	45	45.4	Not specified	SG	Partial
[19]	France	RCS	232	47/185	43.07	40.67 ± 6.87	30	SG	Full
[20]	Italy	RCS	1019	277/742	41.3	44.8 ± 67.4	30	RYGB	Full
[21]	Spain	RCT	180	90/90	NA	NA	NA	RYGB	Full
[22]	Turkey	Cohort Study	216	NA	NA	Not Specified	Not Specified	SG	Partial
[23]	America	RCS	282	NA	43.9	46.4	30	SG	Full
[24]	America	RCS	90	17/73	42	46.3	30	SG	Full
[7]	New York	LCS	21	10/11	17.5	46.3	-	SG	Full
[25]	USA	RCS	173	47/126	50.2	43.6 ± 6.1	90	RYGB	Full
[26]	United Kingdom	Retrospective Analysis	288	Not specified	Not specified	Not specified	30 days	Mixed	Partial
[27]	America	RCT	65	11/54	38.0	44.6	30	SG	Full

ERAS, enhanced recovery after surgery; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy; M, male; Mini, minimally invasive (both laparoscopic and robotic surgeries); RCS, retrospective cohort study; RCT, randomized controlled trial; SC, standard care.; Vertical Sleeve Gastrectomy VSG.

The mean age and BMI of patients in the ERAS group were 39.07 years and 43.70 kg/m^2. The gender ratio of male to female was approximately 0.40. Differences in patient population demographics, such as age, sex, BMI, and comorbidities, can lead to variability in outcomes, as adolescent patients or those with lesser comorbidities may have faster recovery, thus impacting overall heterogeneity. A study by Schmoke *et al.*, showed better outcomes in adolescent age group bariatric surgeries, which may differ from studies focusing on older age group populations [7]. The Forest plot showed symmetrical distribution of studies included, which indicates low risk of publication bias, but minimal asymmetry was seen in studies with smaller sample sizes, thus suggesting the potential influence of missing studies. Egger's Test was employed to evaluate the symmetry of the forest plot (p-value for Intercept (Egger's Test) approximately 0.000000019).It suggested some degree of publication bias or systematic differences in effect sizes reported by smaller studies. The risk of bias due to selective reporting was measured as low across mostly included studies. All included studies reported relevant outcomes, thus reducing the possibility of selective outcome reporting(Figure 2).

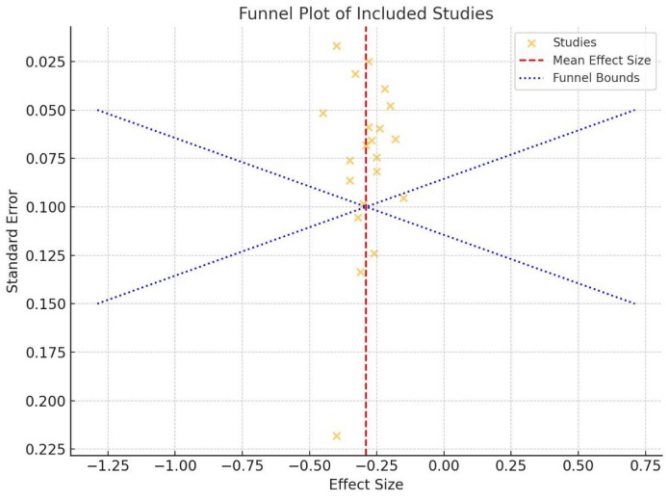

Figure 2: Funnel Plot of Included Studies Distribution

The primary and secondary outcomes across the included studies are given(Table 2).

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Table 2: Outcomes Across Selected Studies

References	Length of Hospitalization (LOH) mean	Overall Complications	Major/Severe Complications	PONV (GI Complaints)	Wound Infections	Intra-abdominal Bleed	Anastomosis Leaks	30 Days Readmission	Revision surgery	Cost	Opioid Discharge Rate
[9]	2.03 days	57.3%	Bleeding 1.3%, Respiratory distress 2.6%	Nausea 21.3%; PONV prophylaxis 95%	NA	1.3%	NA	7.3%	0.6%	NA	NA
[10]	1.79 days	1.9%	13.5%	NA	NA	NA	NA	12.5%	8.8%	€5424.09 (surgery), €775.07 (recovery)	NA
[11]	1.24 days; 86.1% discharged on Day 1	2.9%	Hemorrhage 1.6%, Leak 0.5%, Portal Vein Thrombosis 0.8%	NA	NA	1.6%	0.5%	2.1%	1.3%	NA	NA
[12]	ERAS: 17.4 hours	7.3% (Clavien-Dindo Grade ≥ II)	IIIb: 2.7%	ERAS: Controlled in 1.2 hours (p=0.042)	NA	NA	NA	6.4%	2.7%	NA	NA
[13]	1.2 days	4%	NA	NA	NA	NA	NA	1.5%	NA	NA	NA
[6]	Significant reduction (SD. MD=-2.4, p=0.002)	ERAS 10.1%	ERAS 5%	NA	NA	2.4%	0.8%	6.5%	NA	NA	NA
[14]	1 day shorter than control group	NA	NA	NA	NA	NA	NA	NA	1.3%	3.8% increase	NA
[15]	LSG: 3.2 to 1.5 days, LRYGB: 3.5 to 1.7 days	LSG: 13.8% to 0.8%, LRYGB: 4.2% to 3.0%	LSG: Significant decrease, LRYGB: Similar	NA	NA	NA	NA	LSG: 2.9% to 2.6% and LRYGB: 0% to 4.8%	LSG: 0.7% to 0.5% and LRYGB: 0 to 2.4%	NA	NA
[16]	1.36 days	NA	NA	10.71%	NA	NA	NA	NA	NA	NA	NA
[17]	2.2 days	2.1%	0.4% (ERAS)	Reduced with ERAS	0%	NA	0%	1.3%	NA	NA	NA
[18]	1 day	6.4%	NA	NA	NA	NA	NA	5.4%	2.7%	NA	7.1%
[19]	2.47 days	13.8%	1.3%	6%	2.6%	3.5%	0.9%	6.5%	1.3%	NA	NA
[20]	2.1	3.5%	3.5%, Clavien-Dindo grade III and above	82% PONV free	NA	2.3%	0.5%	0.9%	0.8%	NA	NA
[21]	1.7 days	NA	NA	8.9%	NA	NA	NA	NA	1.1%	NA	NA
[22]	1.2	3.3%	NA	NA	NA	NA	NA	0.9%	NA	625.2 USD	NA
[23]	1.48 days	3.33%	NA	NA	NA	NA	0%	3.74%	0%	NA	44.9% did not need opioids /narcotics
[24]	1.36	3.33%	NA	0%	NA	NA	0%	0%	0%	NA	11%

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[7]	1.5 days	NA	NA	NA	NA	NA	NA	0%	NA	NA	Reduced opioid discharge rate in ERAS group (18.2 vs 97.0 MME)
[25]	1 day	1.7%	1.7%	Significantly lower PONV	NA	NA	NA	8.1%	NA	NA	NA
[26]	81% of patients were discharged by POD 1	NA	NA	NA	NA	NA	NA	6% represent-ation within 30 days	4 patients returned to theatre	NA	NA
[27]	28 hours ERAS	NA	NA	NA	NA	NA	NA	NA	NA	NA	Fewer ERAS patients need opioids/ narcotics in the hospital, 72.3%

Length of hospital stay also had a weak positive correlation with overall complications (r = 0.35) and opioid use reduction (r = 0.28). The LOH was variable across the included studies, with most studies reporting an average stay of approximately 1 to 3 days. A study by Blanchet *et al.*, reported that 86.1% of patients were discharged on the first post-operative day [11], while studies like Mannaerts *et al.*, showed reductions in hospital stay by up to 50% [15].Thus implementation of ERAS protocols reduces hospital stays, which suggests that ERAS is effective in standardizing quicker recovery periods. The average length of hospitalization (LOH) was approximately 1.46 days, with moderate variability (SD=0.47) (Figure 3).

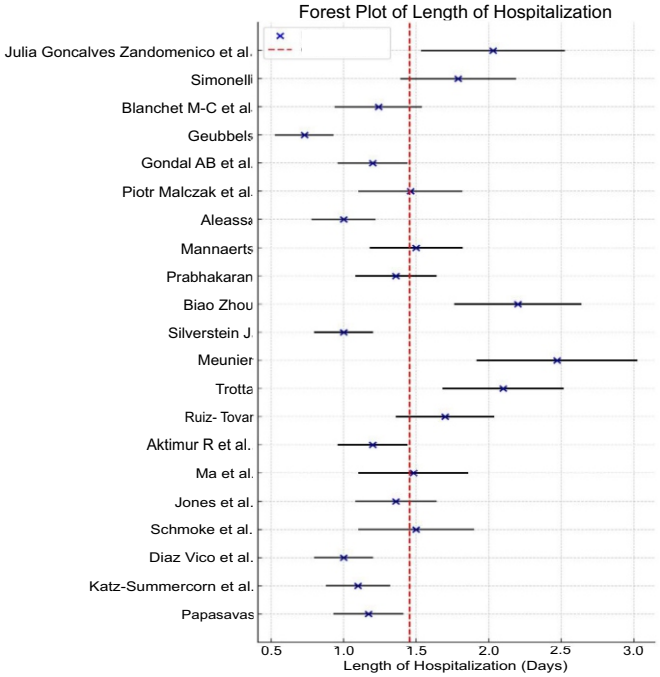

Figure 3: Forest Plot of Length of Hospitalization across Included Studies

The heterogeneity in mixed studies also emphasized the need for clear reporting and separate analysis of SG and RYGB. The subgroup analysis revealed that consistently shorter LOH across the SG subgroup compared to RYGB also supported its use as a low-risk bariatric surgery option for quicker recovery (Figure 4).

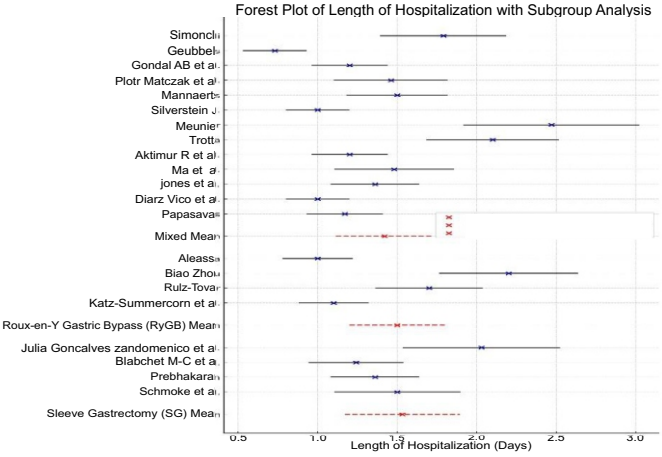

Figure 4: Forest Plot of Subgroup Analysis between SG and RYGB

A study by Zandomenico *et al.*, reported a high incidence of PONV, i.e., 21.3%, but also had a high rate of prophylactic medicine use [9]. Wound infections and anastomotic leaks were not commonly reported across studies but were generally low, as 0% reported by Zhou *et al.* and Jones *et al.* in an ERAS setting [17, 24].The rates of intra-abdominal bleeding were relatively low across studies, 2.4% in Małczak *et al.*, [6] and 1.6% in Blanchet *et al.*, [11], but perioperative monitoring is important in complex bariatric surgeries. The need for revision surgery appears low when ERAS protocols were followed, as Mannaerts reported

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rates of 0 to 2.4% [15]. Katz-Summercorn *et al.*, found that revisional procedures were managed similarly to primary procedures in an ERAS setting without a significant increase in complications [26]. This suggests that ERAS pathways are effective even in more complex surgeries. The readmission rates were low in the majority of studies, between 1% and 6%. Studies like Zhou *et al.*, reported 1.3% [17] and Geubbels [12] 6.4%, low readmission rates with ERAS protocols.

Table 3: Key Metrics of Included Studies

Metric	Studies Count	Mean ± SD	Min	25%	50%	75%	Max
Length of Hospitalization	20	1.46 ± 0.47	0.73	1.13	1.36	1.72	2.47
Overall Complications (%)	15	8.10 ± 14.01	1.7	2.50	3.33	6.85	57.3
Major Complications (%)	8	4.16 ± 4.63	0.4	1.30	2.15	4.88	13.5
30-Day Readmission (%)	16	4.16 ± 3.52	0.0	1.20	3.79	6.43	12.5
Opioid Use Reduction (%)	5	30.70 ± 27.54	7.1	11.00	18.20	44.90	72.3

The complication rates also varied significantly across studies, with some reporting very low rates, e.g., Simonelli *et al.*, with 1.9% [10], and others reporting higher rates, that is, 57.3% by Zandomenico *et al.*, [9]. Studies employing ERAS protocols generally reported lower complication rates e.g., study by Zhou *et el.*, 2.1% [17]. Such variability suggests that surgical techniques, patient selection, comorbidities and the implementation of standardized protocols like ERAS play a significant role in postoperative outcomes. Sleeve Gastrectomy had relatively lower complication rates with a narrower confidence interval as compared to RYGB. The included studies' complication rate (blue dot) and its 95% confidence interval (horizontal line) are displayed (Figure 5).

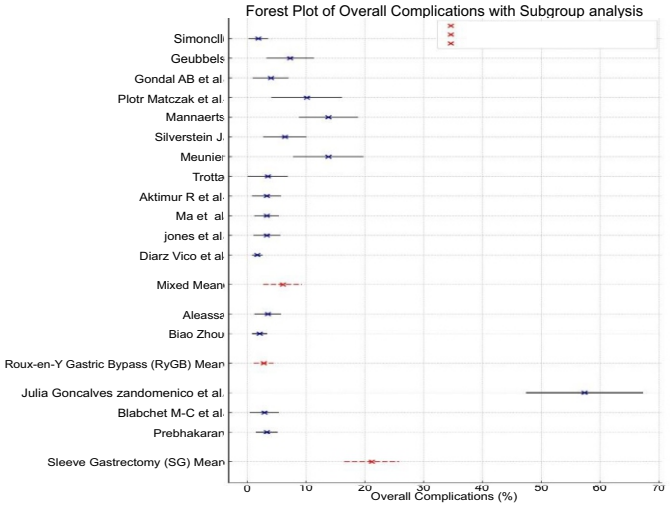

Figure 5: Forest Plot of Overall Complications with Subgroup Analysis

Major complications like anastomosis leakage also showed variability. Simonelli et al. had a relatively high rate of major complications, i.e., 13.5% [10], while others like Małczak and Zhou *et al.*, reported much lower rates below 5% [6, 17]. Katz-Summercorn *et al.* state that revision surgeries were managed similarly to primary in an ERAS setting without a significant increase in complication rates [26], suggesting that ERAS protocols are effective even in more complex bariatric surgeries.Our analysis showed a weak positive correlation (r=0.35) between length of hospitalization and overall complications, which suggests that as complication rates increase, there is a slight tendency for patients to stay longer in the hospital (Table 4).

Table 4: Correlation Analysis of Outcomes

Variables	LOH (Days)	Overall Complications	Major Complications	30-Day Readmission	Opioid Use Reduction
Length of Hospitalization	1.000	0.35	-0.13	0.00	0.28
Overall Complications (%)	0.35	1.000	-0.28	0.24	-0.37
Major Complications (%)	-0.13	-0.28	1.000	-0.18	0.20
30-Day Readmission (%)	0.00	0.24	-0.18	1.000	-0.26
Opioid Use Reduction (%)	0.28	-0.37	0.20	-0.26	1.000

Our analysis showed a moderate negative correlation, r=-0.37, between overall complications and reduction in opioid use, which suggests that hospitals with greater reduction in opioid use tend to have a lower overall complication rate.Opioid use varied across included studies; the study by Ma *et al.*, reported that 44.9% of patients did not require narcotics post-surgery [23]. ERAS protocols were associated with reduced opioid need, as seen in studies like Papasavas *et al.*, [27].The ERAS protocol significantly lowers the use of morphine equivalents for pain management (18.2 mg vs. 97.0 mg; p<0.01) reported by Schmoke *et al.*, [7]. It also reflects the benefit of multimodal analgesia techniques, which reduce opioid dependence and potentially reduce complications associated with opioid use, like nausea and respiratory depression. In our meta-analysis, the overall trend supported a substantial reduction in opioid use across included studies that implemented ERAS protocols

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(Figure 6).

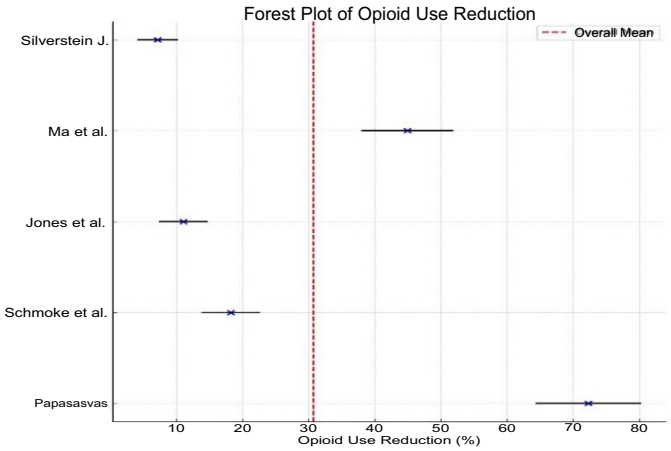

Figure 6: Forest Plot of Opioid Use Reduction

Although direct costing data were not reported by many studies, reduced LOH and complication rate associated with the ERAS protocol were likely to result in reduced overall healthcare budgets.The type of bariatric surgical procedure performed, e.g., laparoscopic sleeve gastrectomy (SG) or Roux-en-Y gastric bypass (RYGB) may also have resulted in different outcomes, e.g., study by Mannaerts *et al.*, showed variability in outcomes based on the type of surgery performed, with SG generally resulting in shorter recovery periods when compared to RYGB [15]. The heterogeneity observed in our meta-analysis was affected by differences in demographics, surgical techniques and ERAS protocol adherence.The major contributor to heterogeneity in our analysis was driven by variability in the number and type of elements implemented across included studies (Figure 7).

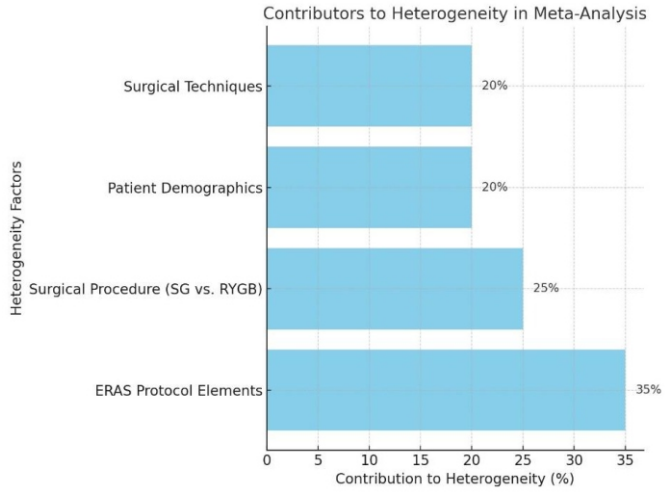

Figure 7: Heterogeneity Contributors in Our Analysis

The regression model was unable to detect any significant relationship between the independent variables (complication rates, readmission rates) and length of hospitalization (dependent variable). This analysis interpreted that reducing complications by 10-30% has a positive impact on reducing hospital stay and improving opioid reduction rates, and it suggests that effective and prompt management of complications significantly accelerates the recovery period and reduces the need for opioids/narcotics post-surgery (Figure 8).

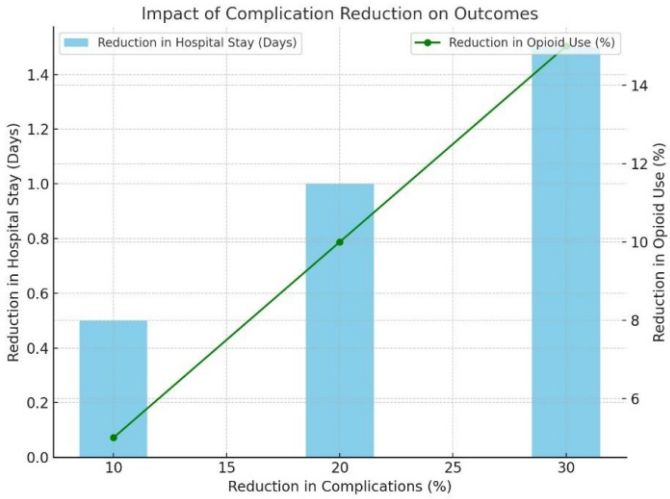

Figure 8: Sensitivity Analysis of Impact of Complication Reduction on Outcomes

DISCUSSION

Enhanced Recovery After Surgery (ERAS) was first introduced in 1995 and refers to a collection of multimodal evidence-based perioperative management strategies which include the following core components, i.e., pre-operative patient preparation and education, nutritional analysis, intraoperative anesthesia protocol, surgical methods and analgesia strategies post-operatively [28]. The ERAS protocol aims to improve surgical outcomes, reduce the perioperative stress response and complications, increase patient satisfaction rates, and have a robust postoperative recovery period [29].This meta-analysis includes evidence from 21 studies, carried out in different countries and ethnic groups, to assess the impact of ERAS principles on bariatric surgery outcomes. These meta-analytic findings support the superiority of ERAS protocols over conventional care in reducing hospital stays and post-operative recovery. Studies included in this meta-analysis, like Blanchet *et al.*, and Mannaerts *et al.*, show a reduction in hospitalization by up to 50%, hence emphasizing the ERAS protocol's effectiveness in standardizing quicker recovery periods [11, 15]. In this meta-analysis, a significant correlation was found for the weak positive relationship (r=0.35) between LOH and overall complication rates, revealing that high complications slightly extend hospital stays.This observation is also supported in a study by Małczak *et al.*, [6], in which a complication rate of 10.1% was associated with longer LOH. In contrast, studies with low complication rates, 2.1% in Zhou *et al.*, [17], generally reported shorter recovery periods. Study by Thorell *et al.*, [30]. On ERAS in bariatric surgery, also reported significant reduction in

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hospital stays, with most patients being discharged within 1 to 3 days, which is comparable to our analysis.Thorell *et al*, also reported an overall complication rate of around 7.5% with implementation of ERAS protocols [30], similar to 8.10% in this analysis.This meta-analysis also highlights a moderate negative correlation (r =-0.37) between overall complications and opioid reduction rate, which reveals that hospitals utilizing more multimodal analgesia techniques central to ERAS elements experienced fewer complication rates.A study by Feldheiser *et al.*, reported that opioid sparing protocols led to reductions of 40-70% in opioid consumption, similar to our analysis findings [31].This meta-analysis is comparable with other analyses, i.e., with Awad *et al.*, [32] and Stenberg *et al.*, [8], but the main difference lies in the quality of evidence.Our analysis included a broader range of recently conducted studies, allowing for a more comprehensive evaluation of ERAS effectiveness in bariatric surgery, while their studies excluded several bariatric surgery-specific key ERAS elements due to low evidence quality and thus led to heterogeneity.The study by Trotta *et al.*, [20], published in 2024 and conducted in high-volume centers, provides more valuable insights into the implementation of ERAS principles in diverse settings. A study by Schmoke *et al.*, [7].Conducted in 2024, focused on adolescent age range bariatric surgeries and improved outcomes,suggested that ERAS protocols are beneficial across various patient demographics.This diverse variety of included studies in our meta-analysis supports the applicability and versatility of ERAS protocols in different patient demographics and ethnic populations.The ERAS protocols not only reduce hospitalization duration but also improve utilization of ICU resources as evident in a meta-analysis by Davey *et al.*, [33], who quantify reductions in ICU stay (MD: 0.70, p=0.02) and time to mobilization (MD: -3.78, p<0.001). Besides, Davey *et al.*, observed no significant statistical difference in overall (11.8%) and major complications (3.4%) between the ERAS and SC group [33].The findings of another study by Huh and Kim [34] aligns with this meta-analysis, demonstrating that ERAS protocol implementation significantly lessens postoperative pain (mean difference [MD]:−1.2, 95% confidence interval [CI]: −2.0 to −0.4, p=0.003), nausea and vomiting (odds ratio [OR]: 0.55, 95% CI: 0.32–0.91, p=0.021), and length of hospital stay (MD:−0.8 days, 95% CI:−1.1 to −0.5, p<0.001) without increase in morbidity. Their study also highlights opioid-sparing multimodal pain management strategies and optimal goal-directed postoperative fluid therapy as structural key elements in optimizing robust recovery, which is consistent with this meta-analysis. The study by Doshi *et al.*, [35] demonstrated that the implementation of the ERAS protocol in patients who underwent bariatric surgery resulted in a significant reduction in length of hospital stay (LOS) by 1 day (p=0.001) and median cost reductions of $2230 per patient (p<0.001). The exact data on cost savings were not explicitly analyzed in this meta-analysis, making it difficult to quantify and compare the exact financial impact.The Italian Consensus Statement on Enhanced Recovery After Bariatric Surgery (ERABS) also concludes that ERAS implementation significantly reduces length of hospital stay compared to conventional bariatric surgery protocols [36].The Consensus also highlights the multimodal analgesia strategy as a fundamental key element, thus aligning with this meta-analysis, which demonstrates a significant reduction in opioid consumption and opioid-related adverse events. Despite the overall positive outcomes, this meta-analysis revealed significant heterogeneity among the included studies, particularly in ERAS protocol components and implementation practices.This variability suggests a need for standardized ERAS guidelines tailored to bariatric surgery specifically to enhance consistency in patient outcomes.Our meta-analysis also included different study designs, while most included were RCTs, others were retrospective or observational studies that may cause bias and influence the study outcomes. Few studies also lacked sufficient blinding and detailed methodology, hence making it difficult to fully assess their quality.Many studies included were conducted in high-volume surgical centers where ERAS implementation was better established, which may not reflect outcomes in low-volume settings.

Currently, developing countries are facing many healthcare challenges and resource constraints, but the implementation of ERAS protocols could significantly improve surgical postoperative outcomes, enhance patient satisfaction rates and reduce healthcare budgets. Future large-scale RCTs should be conducted to identify the most impactful and uniformly consistent core elements of ERAS protocols to ensure optimal applicability across different clinical settings and surgical techniques.

CONCLUSIONS

This meta-analysis concluded that ERAS protocols' implementation in modern-era bariatric surgeries supports the positive role of these protocols due to short hospital stays, decreased recovery periods, and increased patient satisfaction. The findings affirm that ERAS protocols lead to shorter hospital stays (by an average of 1.5 days), reduced post-operative complications, and low opioid consumption, thus contributing to faster recovery periods.

Authors' Contribution

Conceptualization: MAJ
Methodology: MI, AA, MH, NF
Formal analysis: MI, NF
Writing and Drafting: MAJ, AA, MA, MMG
Review and Editing: MAJ, AA, MA, MMG

All authors approved the final manuscript and take responsibility for the integrity of the work

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Conflicts of Interest

All the authors declare no conflict of interest.

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