Balkan Med J 2025;42:14-26

Efficacy and Safety of a Combination of Enteral and Parenteral Nutrition Support in the Postoperative Period for Patients with Gastrointestinal Cancer: A Systematic Review and Meta-Analysis

Meixiang Cai[1#], Bo Yang[2#], Yaping Zheng[3], Lei Ding[4]

[1]Department of Nursing, Changzhou Maternal and Child Health Care Hospital, Changzhou, China
[2]Department of Urology and Hepatobiliary Surgery, Changzhou Maternal and Child Health Care Hospital, Changzhou, China
[3]Department of Oncology, Liyang People's Hospital, Changzhou, China
[4]Department of Gastrointestinal Surgery, Changzhou Maternal and Child Health Care Hospital, Changzhou, China
[#]These authors contributed equally.

Background: Postoperative nutritional support in gastrointestinal cancer, including enteral nutrition (EN), parenteral nutrition (PN), and combined nutrition strategies, is vital for enhancing recovery and patient outcomes.

Aims: We aimed to comprehensively evaluate the impact of postoperative EN, PN, and EN + PN in patients with gastrointestinal cancer.

Methods: PubMed, Embase, Cochrane Library, Web of Science, CNKI, Wan Fang, and VIP were searched from conception until January 2, 2024. Randomized controlled trials (RCTs) that compared different postoperative nutritional support (EN, PN, or EN + PN) in patients with gastrointestinal cancer were included. The Cochrane Risk of Bias Assessment tool was used to assess the quality of the RCTs. Fixed- and random-effects models were chosen according to the heterogeneity of variables for the synthesis of results. Continuous and categorical variables were analyzed using the weighted mean difference or relative risk (RR) and 95% confidence interval (CI).

Results: In this meta-analysis, 11 RCTs were included. The PN + EN group exhibited significantly improved postoperative recovery, nutritional function, and immune indicators than the PN and EN groups ($p < 0.05$). Additionally, a higher incidence of postoperative complications such as abdominal distension (RR: 2.53; 95% CI: 1.17-5.49), nausea/vomiting (RR: 2.01; 95% CI: 1.09-3.71), and diarrhea (RR: 3.17; 95% CI: 1.41-7.10) was observed in the EN group than in the PN + EN group.

Conclusion: Combining supplemental PN with enteral support improves energy intake and prognosis in gastrointestinal cancer, though limited studies restrict publication bias evaluation.

INTRODUCTION

Recognized as one of the most prevalent and fatal types of cancer, gastrointestinal cancer imposes a burden on health and economics.[1] Statistics indicate that gastrointestinal cancers contribute to a quarter of all cancer incidences and a third of cancer-related fatalities globally.[2] Gastrointestinal cancers are recognized as consumptive diseases, which are frequently accompanied by malnutrition and impaired immune function when the patient is in a state of high catabolism for a prolonged period.[3] Surgical resection is typically the foundation of radical therapy for gastrointestinal cancers.[4] However, surgical resection can often result in significant nutritional deficiencies due to limited food intake, poor digestion, and malabsorption.[5] Postoperative malnutrition increases the risk of infection, delays wound healing, and may be associated with a poor overall survival rate and recurrence-free survival rate in patients with gastrointestinal cancer.[6,7] The nutrition of patients can significantly affect the recovery and prognosis of patients with gastrointestinal cancer.[8] Thus, appropriate postoperative nutritional assistance is critical for the management of patients with gastrointestinal cancer.

Postoperative nutritional support for patients with gastrointestinal cancers can be provided via several methods, including enteral nutrition (EN), parenteral nutrition (PN), and a combination of both

Corresponding author: Lei Ding, Department of Gastrointestinal Surgery, Changzhou Maternal and Child Health Care Hospital, Changzhou, China
e-mail: dinglei278_DL@163.com

Received: October 15, 2024 **Accepted:** November 03, 2024 **Available Online Date:** January 02, 2025 • **DOI:** 10.4274/balkanmedj.galenos.2024.2024-10-65
Available at www.balkanmedicaljournal.org

ORCID iDs of the authors: M.C. 0009-0008-4264-0299; B.Y. 0009-0006-4422-1819; Y.Z. 0009-0005-9400-1251; L.D. 0009-0000-8348-7501.

Cite this article as: Cai M, Yang B, Zheng Y, Ding L. Efficacy and Safety of a Combination of Enteral and Parenteral Nutrition Support in the Postoperative Period for Patients with Gastrointestinal Cancer: A Systematic Review and Meta-Analysis. Balkan Med J.; 2025; 42(1):14-26.

(EN + PN).[9] Generally, providing nutrients directly into the digestive tract via a percutaneous endoscopic gastrostomy or nasogastric tube is defined as EN.[10] EN is frequently regarded as the optimum nutritional support in clinics because it promotes immune function, preserves gut integrity, and lowers the risk of infection.[11] PN is a form of nutritional therapy that involves the intravenous administration of nutrients. PN is regarded as a crucial approach to preventing malnutrition in specific patients in whom the gastrointestinal tract is impaired or fails to meet nutritional requirements.[12] However, both methods are associated with some disadvantages. Patients receiving PN are prone to bacterial translocation, surgical problems, and poor recovery,[13] whereas patients receiving EN are prone to food intolerance.[14] Feeding intolerance, which often manifests as gastrointestinal symptoms (e.g., large gastric residual volume, vomiting, bloating, and diarrhea), interferes with the effective absorption of nutrients and exacerbates malnutrition.[15] The European Society for Parenteral and Enteral Nutrition guidelines for the intensive care unit explicitly state that when a patient's nutritional demands cannot be addressed with EN, PN should be administered as a supplement.[16] Furthermore, studies have demonstrated that supplementing PN with EN significantly improves energy intake and prognosis.[17,18] Thus, the combination of EN and PN might be the optimal clinical nutritional support.

Previous studies have reported inconsistent results of the three nutritional supports (EN, PN, and EN + PN) in terms of postoperative recovery, complication rates, and overall survival. For instance, Wang et al.[19] discovered that there was no difference in the duration of hospital stay among patients with gastrointestinal cancer who received different nutritional supports (PN vs. EN + PN). However, another study[20] conducted in patients 3 months after surgery determined that the patients in the EN + PN group exhibited superior physical function and energy/fatigue scores than the patients in the EN group. Most current studies have focused on the efficacy of a single nutritional support during the postoperative period in patients with gastrointestinal cancer. Furthermore, existing evidence on the postoperative efficacy of EN, PN, and EN + PN in patients with gastrointestinal cancer is inconsistent, and there is a lack of comprehensive evaluation studies. Therefore, herein, we conducted a meta-analysis of various randomized controlled trials (RCTs) that have investigated postoperative nutritional support (PN, EN, and EN + PN) in patients with gastrointestinal cancer. Our study findings may contribute to a more thorough assessment of the efficacy of nutritional support (PN, EN, and EN + PN) during the postoperative period in patients with gastrointestinal cancer, providing physicians with a foundation for selecting the best nutritional support.

MATERIALS AND METHODS

Literature screening

The literature was systematically reviewed according to the principles of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)[21] and the Cochrane Handbook for Systematic Reviews of Intervention.[22] PubMed, Embase, Cochrane Library, Web of Science, the China National Knowledge Infrastructure, Wanfang Data, and the China Science and Technology Journal Database were searched from inception to January 2, 2024. The searches were conducted using a combination of subject terms and free words (Supplementary Table 1).

Inclusion and exclusion criteria

Based on the Population, Intervention, Comparison, Outcomes and Study principles,[23] the following comprehensive inclusion criteria were outlined:

- **Participants:** Patients with gastrointestinal cancer who had undergone surgical treatment.

- **Interventions and comparisons:** Studies comparing different postoperative nutritional support (EN, PN, or EN + PN).

- **Outcomes:** Postoperative recovery indicators that included the time-to-first flatus, time-to-first feces, and duration of hospital stay. Nutritional indicators that included albumin (ALB), prealbumin (PA), transferrin (TF), and hemoglobin (HGB) levels. Immunological indicators that included immunoglobulin A (IgA), IgG, IgM, cluster of differentiation 3 ($CD3^+$), $CD4^+$, and $CD8^+$ levels, as well as $CD4^+/CD8^+$ ratios. Postoperative complications that included abdominal pain, abdominal distension, diarrhea, nausea/vomiting, surgical wound infection, and anastomotic fistula.

- **Study design:** All RCTs were included.

Studies with the following characteristics were excluded from the analysis: animal experiments, review/literature review, note, conference abstract, expert consensus, guidelines, trail, registry record, meta-analysis, study protocol, letter, editorial, summary, conference paper, short survey, and articles not relevant to the investigated topic.

Data extraction

A flowchart based on PRISMA (Figure 1) was utilized to illustrate the literature search process, including the screening process, exclusion criteria, and the specific number of articles. First, duplicate studies were removed using EndNote X9. Thereafter, two reviewers independently screened the abstracts of the retrieved articles to ensure that all the included studies were relevant. Subsequently, the full texts of the studies were screened by two reviewers. In the case of studies conducted by the same authors and involving the same study populations, only those with complete data were selected to avoid data duplication. Two reviewers independently gathered data from the eligible studies. Any disagreements were discussed and resolved via consultation with a third reviewer. A predetermined questionnaire was utilized to extract the following relevant data: i) fundamental details of the included studies such as article title, authors, and publication year; ii) basic characteristics of the study participants such as sample size, age, and sex distribution; iii) specific intervention particulars, including intervention content and duration; and iv) outcome indicators and the corresponding measurement data.

Evaluation of the literature quality

The Cochrane Collaboration Tool[24] was used to assess the quality of the RCTs. The included studies were scored on the basis of the following seven items: randomization sequence generation, allocation concealment, double blinding of investigators and participants, blinding of outcome assessment, incomplete outcome data, selective publication, and other biases.

TABLE 1. The Characteristics of the Included Studies.

First author	Year	Country	Study design	Population	Intervention	n	Male/female	Age (year)	Course of treatment (day)
Chen	2019	China	RCT	Elderly patients with colorectal cancer after surgery	PN	50	32/18	67.2 0±5.10	7
					EN + PN	50	34/16	67.60±5.20	7
Li	2015	China	RCT	Undergoing surgical therapy for gastric cancer	PN	45	25/20	62.50±5.30	7
					EN + PN	45	25/20	62.50±5.30	7
Huang	2015	China	RCT	Old patients receiving surgery for GI cancer	PN	35	NA	66.10±8.10	7
					EN	35	NA	66.70±7.20	7
					EN + PN	35	NA	67.20±7.90	7
Liu	2009	China	RCT	Elderly gastric cancer patients after surgery	PN	50	NA	NA	7
					EN	51	NA	NA	7
					EN + PN	52	NA	NA	7
Peng	2010	China	RCT	Colon cancer surgery patient	PN	32	18/14	63.74±10.34	7
					EN + PN	32	18/14	63.43±10.13	7
Chen	2013	China	RCT	Patients with gastric cancer after radical surgery	PN	34	19/15	51.00±5.90	7
					EN + PN	34	21/13	51.00±9.80	7
Liu	2013	China	RCT	Elderly gastric cancer patients after surgery	PN	44	26/18	74.20±7.60	7
					EN + PN	43	29/14	75.80±5.50	7
Ma	2018	China	RCT	Surgical resection of colorectal cancer patients	PN	53	26/27	55.90±10.80	7
					EN	53	29/24	56.40±12.30	7
					EN + PN	53	28/25	57.40±9.70	7
Xie	2023	China	RCT	Patients undergoing radical gastrectomy	EN	60	34/26	43.79±8.36	7
					EN + PN	60	32/28	45.36±8.28	7
Hao	2023	China	RCT	Patients undergoing radical gastrectomy	EN	34	19/15	51.73±7.45	7
					EN + PN	34	21/13	51.86±8.30	7
Gao	2023	China	RCT	Colorectal cancer patients undergoing radical surgery	EN	50	27/23	52.39±4.02	7
					EN + PN	50	28/22	52.54±3.97	7

RCT, randomized controlled trial; EN, enteral nutrition; PN, parenteral nutrition; N, number of samples; NA, not applicable.

Statistical analysis

The weighted mean difference (WMD) was employed as the effect indicator for the continuous variables, whereas the relative risk (RR) was utilized for the categorical variables. The effect sizes were subsequently expressed as 95% confidence intervals (CIs). Heterogeneity was assessed separately for each outcome variable using the statistical value I^2. If the I^2 was > 50%, a random-effects model was utilized. If the I^2 was < 50%, a fixed-effects model was employed. Sensitivity analyses were conducted using the leave-one-out approach, excluding the study with the highest risk of bias or the smallest sample sizes, to ensure that the findings remained robust. Statistical analyses were performed using Stata (version 15.1). In addition, RevMan (version 5.3) was employed to generate the risk of bias plots and summary plots, which were used to assess the quality of RCTs. Statistical significance was determined at a two-tailed p value of < 0.05.

RESULTS

Characteristics of the eligible studies

Initially, 7,095 records were retrieved from the databases using the search strategy. After eliminating duplicates and reviewing the titles and abstracts, 36 studies were selected for full-text verification. Finally, 11 studies (Supplementary material of included literature) were included in the meta-analysis (Figure 1).

Table 1 presents the characteristics of the enrolled studies. The 11 included studies were all RCTs and had been published between 2009 and 2023. The sample sizes of the studies varied from 32 to 60, exhibiting a close approximation. The standard treatment course lasted for 7 days, and the average age of the study participants ranged from 43.79 to 75.80 years. All the included studies focused on patients with gastric cancer and colorectal cancer. In three of the 11 studies, all three postoperative nutritional support therapy (EN, PN, and EN + PN) were compared. In five studies PN was compared with EN + PN, while in three studies, EN was compared with EN + PN.

Quality evaluation and research bias

To evaluate the bias for each study, risk of bias plots and summary plots were generated. Incomplete outcome data and blinding of outcome assessment were considered a low risk of bias, while allocation concealment was considered a high risk of bias (Supplementary Figure 1). After summarizing the risk of bias for the included studies (Supplementary Figure 2), we found that the study by Liu[25] exhibited the highest risk of bias. Most of the other studies exhibited a risk bias level of two items. In general, the risk of bias in the meta-analysis was acceptable.

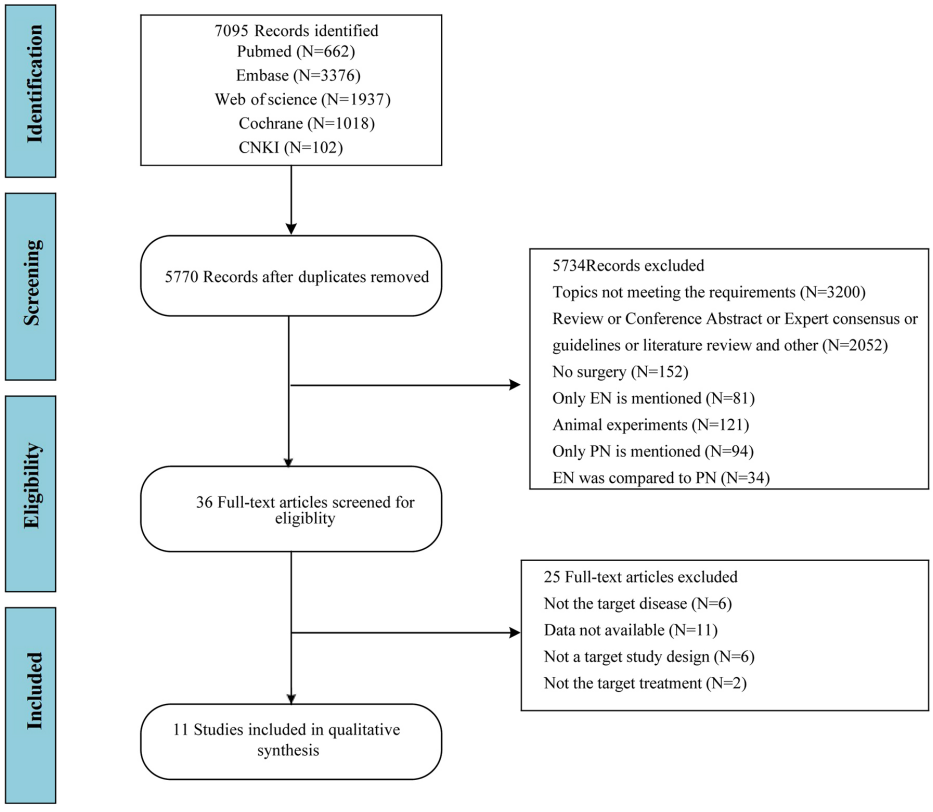

FIG. 1. Flow chart of the process of study selection.
EN, enteral nutrition, PN, parenteral nutrition.

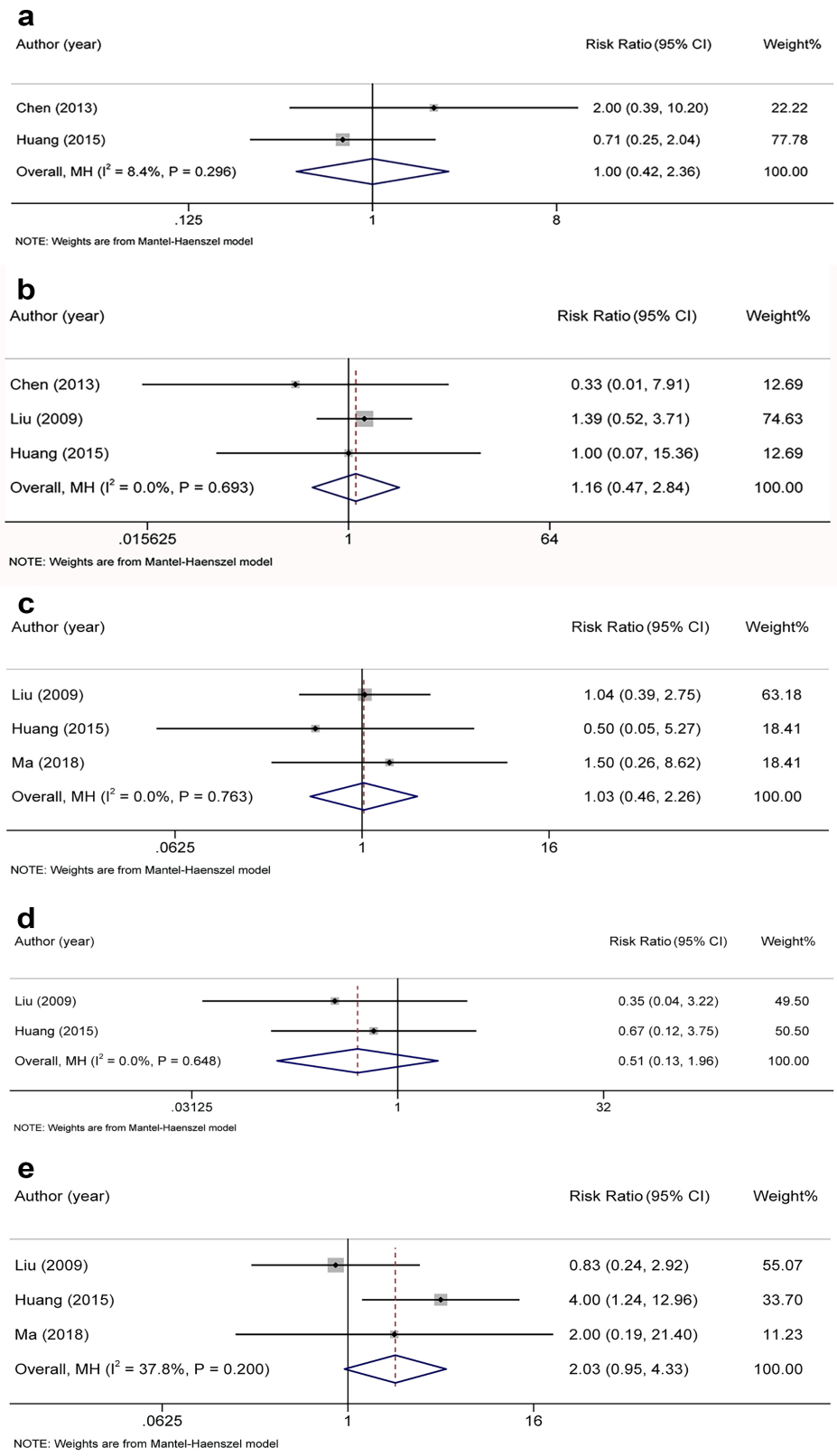

FIG. 2. Postoperative complication indicators in the PN and EN + PN groups: (a) abdominal pain, (b) abdominal distension, (c) nausea/vomiting, (d) diarrhea, and (e) surgical wound infection.

CI, confidence interval; EN, enteral nutrition, PN, parenteral nutrition.

Comparison of postoperative PN and EN + PN in patients with gastrointestinal cancer

The postoperative recovery indicators were compared between the PN and EN + PN groups. Because the heterogeneity among the studies was significant ($I^2 > 50\%$), a random-effects model was used for the combined effect analysis of the postoperative indicators. The time-to-first flatus, time-to-first feces, and duration of hospital stay were longer in the PN group than in the EN + PN group (Table 2). The WMD of the time-to-first flatus, time-to-first feces, and duration of hospital stay were 1.63 (95% CI: 1.41-1.86), 1.07 (95% CI: 0.82-1.33), and 1.16 (95% CI: 0.96-1.36), respectively ($p < 0.001$ for all).

The postoperative nutritional functioning were compared between the PN and EN + PN groups using the ALB, PA, TF, and HGB levels. A fixed-effects model was used to analyze the HGB levels ($I^2 = 50\%$), while a random-effects model was used to analyze the ALB, PA, and TF ($I^2 > 50\%$). The PN group exhibited lower levels of ALB, PA, and TF ($p < 0.05$) than the EN + PN group (Table 2). However, there was no difference in the HGB levels between the two groups (WMD: 0.13; 95% CI: -0.20 to 0.47).

A random-effects model was used to analyze the immune indicators, except the $CD4^+/CD8^+$ ratio ($I^2 = 20.2\%$), between the PN and EN + PN groups (Table 2). The levels of IgA (WMD: -0.72), IgG (WMD: -0.53), IgM (WMD: -0.83), $CD3^+$ (WMD: -1.56), and $CD4^+$ (WMD: -0.93), and the $CD4^+/CD8^+$ ratio (WMD: -0.54) were lower in the PN group than in the EN + PN group (all $p < 0.05$). However, there was no difference in the C3 (WMD: 0.25; 95% CI: -0.59 to 0.10) and $CD8^+$ (WMD: 0.04; 95% CI: -0.24 to 0.16) levels between the two groups.

To investigate the safety of alternative postoperative nutritional therapies, the incidences of postoperative complications in the two groups were compared (Figure 2). The heterogeneity of the studies within each subgroup ($I^2 < 50\%$) did not exhibit any differences. Thus, a fixed-effects model was used for the meta-analysis. There were no differences in the postoperative complications (nausea/vomiting, diarrhea, surgical wound infection, abdominal discomfort, and abdominal distension) between the two groups (all $p > 0.05$).

Comparison of postoperative EN and EN + PN in patients with gastrointestinal cancer

Table 3 demonstrates the postoperative recovery of the EN and EN + PN groups. The random-effects model ($I^2 > 50\%$) revealed that the time-to-first flatus, time-to-first feces, and duration of hospital stay were shorter in the EN+PN group than in the EN group (all $p < 0.001$).

The nutritional indicators were analyzed using random-effects models ($I^2 > 50\%$; Table 3). The levels of ALB, PA, HGB, and TF were lower in the EN group than in the EN + PN group, with WMDs of -1.09 (95% CI: -1.27 to -0.91), -1.20 (95% CI: -1.40 to -0.99), -0.76 (95% CI: -1.09 to -0.44), and -0.60 (95% CI: -0.79 to -0.42), respectively.

In the analysis of immunological indicators, sufficient data were collected for the analysis of only $CD3^+$ and $CD4^+$ levels and the $CD4^+/CD8^+$ ratio (Table 3). The random-effects models demonstrated that the $CD3^+$ level ($I^2 = 90.7\%$; WMD: -0.71; 95% CI: -0.95 to -0.47) and $CD4^+/CD8^+$ ration ($I^2 = 92.4\%$; WMD: -0.84; 95% CI: -1.08 to -0.59) were significantly lower in the EN group than in the EN + PN group. There was no statistically significant difference in the $CD4^+$ levels between the two groups ($p > 0.05$).

The fixed-effects model ($I^2 = 0\%$) revealed that the incidences of abdominal distension (RR: 2.53; 95% CI: 1.17-5.49), diarrhea (RR: 3.17; 95% CI: 1.41-7.10), and nausea/vomiting (RR: 2.01; 95% CI: 1.09-3.71) were higher in the EN group than in the EN + PN group (Figure 3). There was no difference in the risk of surgical wound infection and anastomotic fistula formation between the two groups ($p > 0.05$).

Sensitivity analysis and publication bias

There were no changes in the direction and margin of the composite estimates (Tables 2, 3), indicating that the results are stable and that individual studies did not excessively affect the results. In this meta-analysis, publication bias was not evaluated because each outcome included data from no more than ten studies.[26]

DISCUSSION

To examine the efficacy and safety of postoperative nutritional support therapy (EN, PN, and EN + PN) in patients with gastrointestinal cancer, 11 RCTs were included in our meta-analysis. Our study results demonstrated the that postoperative recovery, nutritional status, and immune status of patients with gastrointestinal cancer were significantly better in the EN + PN group than in the EN or PN groups. However, there were significant differences in the postoperative complications only between the EN and EN + PN groups.

Typically, EN is more effective than PN in the postoperative recovery of patients with gastrointestinal malignancies.[27,28] A meta-analysis conducted by Yan et al.[27] demonstrated that EN can reduce the incidence of postoperative complications and length of hospital stay. Another meta-analysis comparing the efficacies of PN and EN demonstrated that patients treated with EN had shorter hospital stays, shorter time-to-flatus, and significantly increased ALB levels than patients who were administered total PN after abdominal surgery.[28] However, patients being treated with EN are prone to malnutrition due to EN intolerance.[14] A recent study suggested that postoperative recovery is significantly better with EN + PN administration than with EN or PN administration.[29] An observational cross-sectional study in 536 adult patients undergoing major gastrointestinal surgery demonstrated that the lowest caloric/protein deficiency was observed in those receiving EN + PN, followed by those receiving PN alone and those receiving EN alone.[30] Wu et al.[20] determined that early postoperative PN supplementation contributes to the patient's full caloric requirement, which may be associated with the supply of calories and protein. In a meta-analysis evaluating the effects of postoperative EN + PN and EN in patients with gastric cancer, the EN + PN group exhibited a shorter hospital stay and lower rate of postoperative complications than the EN group. However, there was no difference in the time-to-first flatus between the two groups.[31] Consistent with previous

TABLE 2. Comparing EN + PN with PN in Patients After Surgery for Gastrointestinal Cancer.

Outcomes	Indicators	N of studies	WMD/RR (95% CI)	p	I^2 (%)
Complications					
Abdominal pain	Overall	2	1.00 (0.42, 2.36)	1,000	8.4
	Sensitive analysis[a]	2	1.00 (0.42, 2.36)		
	Sensitive analysis[b]	2	1.00 (0.42, 2.36)		
	Sensitive analysis[c]	-	-		
Abdominal distension	Overall	3	1.16 (0.47, 2.84)	0.743	0.0
	Sensitive analysis[a]	3	1.16 (0.47, 2.84)		
	Sensitive analysis[b]	2	1.33 (0.53, 3.35)		
	Sensitive analysis[c]	2	0.50 (0.47, 5.39)		
Nausea/vomiting	Overall	3	1.03 (0.46, 2.26)	0.951	0.0
	Sensitive analysis[a]	3	1.03 (0.46, 2.26)		
	Sensitive analysis[b]	2	1.14 (0.49, 2.67)		
	Sensitive analysis[c]	2	1.00 (0.26, 3.89)		
Diarrhea	Overall	2	0.51 (0.13, 1.96)	0.327	0.0
	Sensitive analysis[a]	2	0.51 (0.13, 1.96)		
	Sensitive analysis[b]	2	0.51 (0.13, 1.96)		
	Sensitive analysis[c]	-	-		
Incision infection	Overall	3	2.03 (0.95, 4.33)	0.067	37.8
	Sensitive analysis[a]	3	2.03 (0.95, 4.33)		
	Sensitive analysis[b]	2	1.02 (0.34, 3.07)		
	Sensitive analysis[c]	-	-		
Postoperative recovery					
Time to first flatus	Overall	5	1.63 (1.41, 1.86)	<0.001	94.7
	Sensitive analysis[a]	5	1.63 (1.41, 1.86)		
	Sensitive analysis[b]	4	1.77 (1.51, 2.02)		
	Sensitive analysis[c]	4	1.34 (1.10, 1.57)		
Time to first feces	Overall	3	1.07 (0.82, 1.33)	<0.001	69.6
	Sensitive analysis[a]	3	1.07 (0.82, 1.33)		
	Sensitive analysis[b]	2	1.26 (0.96, 1.56)		
	Sensitive analysis[c]	-	-		
Duration of hospital stay	Overall	5	1.16 (0.96, 1.36)	<0.001	53.2
	Sensitive analysis[a]	5	1.16 (0.96, 1.36)		
	Sensitive analysis[b]	4	1.08 (0.86, 1.29)		
	Sensitive analysis[c]	4	1.30 (1.07, 1.53)		
Nutritional indicators					
ALB (g/L)	Overall	6	-0.21 (-0.39, -0.04)	0.016	90.0
	Sensitive analysis[a]	6	-0.21 (-0.39, -0.04)		
	Sensitive analysis[b]	5	-0.24 (-0.43, -0.05)		
	Sensitive analysis[c]	5	-0.45 (-0.65, -0.26)		
PA (mg/L)	Overall	4	-1.20 (-1.43, -0.97)	<0.001	91.9
	Sensitive analysis[a]	4	-1.20 (-1.43, -0.97)		
	Sensitive analysis[b]	3	-1.57 (-1.84, -1.31)		
	Sensitive analysis[c]	-	-		

TABLE 2. Continued

Outcomes	Indicators	N of studies	WMD/RR (95% CI)	p	I^2 (%)
TF (g/L)	Overall	5	-0.42 (-0.61, -0.23)	<0.001	87.5
	Sensitive analysis[a]	5	-0.42 (-0.61, -0.23)		
	Sensitive analysis[b]	4	-0.52 (-0.73, -0.31)		
	Sensitive analysis[c]	4	-0.56 (-0.78, -0.34)		
HGB (g/L)	Overall	2	0.13 (-0.20, 0.47)	0.439	0.0
	Sensitive analysis[a]	2	0.13 (-0.20, 0.47)		
	Sensitive analysis[b]	2	0.13 (-0.20, 0.47)		
	Sensitive analysis[c]	-	-		
Immunological indicators					
IgA	Overall	6	-0.72 (-0.90, -0.54)	<0.001	77.3
	Sensitive analysis[a]	6	-0.72 (-0.90, -0.54)		
	Sensitive analysis[b]	5	-0.74 (-0.94, -0.55)		
	Sensitive analysis[c]	-	-		
IgG	Overall	6	-0.53 (-0.70, -0.35)	<0.001	86.6
	Sensitive analysis[a]	6	-0.53 (-0.70, -0.35)		
	Sensitive analysis[b]	5	-0.53 (-0.72, -0.33)		
	Sensitive analysis[c]	-	-		
IgM	Overall	6	-0.83 (-1.01, -0.65)	<0.001	58.6
	Sensitive analysis[a]	6	-0.83 (-1.01, -0.65)		
	Sensitive analysis[b]	5	-0.91 (-1.10, -0.71)		
	Sensitive analysis[c]	-	-		
C3	Overall	2	-0.25 (-0.59, 0.10)	0.160	66.3
	Sensitive analysis[a]	2	-0.25 (-0.59, 0.10)		
	Sensitive analysis[b]	2	-0.25 (-0.59, 0.10)		
	Sensitive analysis[c]		-		
$CD3^+$ (%)	Overall	5	-1.56 (-1.80, -1.33)	<0.001	89.4
	Sensitive analysis[a]	5	-1.56 (-1.80, -1.33)		
	Sensitive analysis[b]	4	-1.69 (-1.95, -1.43)		
	Sensitive analysis[c]	-	-		
$CD4^+$ (%)	Overall	5	-0.93 (-1.15, -0.72)	<0.001	88.0
	Sensitive analysis[a]	5	-0.93 (-1.15, -0.72)		
	Sensitive analysis[b]	4	-1.03 (-1.26, -0.79)		
	Sensitive analysis[c]	-	-		
$CD8^+$ (%)	Overall	5	-0.04 (-0.24, 0.16)	0.706	71.2
	Sensitive analysis[a]	5	-0.04 (-0.24, 0.16)		
	Sensitive analysis[b]	4	-0.02 (-0.23, 0.20)		
	Sensitive analysis[c]	-	-		
$CD4^+/CD8^+$ (%)	Overall	5	-0.54 (-0.74, -0.34)	<0.001	20.2
	Sensitive analysis[a]	5	-0.54 (-0.74, -0.34)		
	Sensitive analysis[b]	4	-0.48 (-0.70, -0.26)		
	Sensitive analysis[c]	-	-		

EN, enteral nutrition; PN, parenteral nutrition; N, number of samples; NA, not applicable; WMD, weighted mean difference; RR, relative risk; CI, confidence interval; ALB, albumin; PA, prealbumin; TF, transferrin; HGB, hemoglobin; IgA, immunoglobulin, IgG, immunoglobulin G; IgM, immunoglobulin M; $CD3^+$, cluster of differentiation 3; $CD4^+$, cluster of differentiation 4; $CD8^+$, cluster of differentiation 8. [a]Sensitivity analysis was conducted by leave-one-out approach; [b]Sensitivity analysis was conducted by removing smallest study; [c]Sensitivity analysis was conducted by removing study with highest risk of bias.

TABLE 3. Comparing EN + PN with EN in Patients After Surgery for Gastrointestinal Cancer.

Outcomes	Indicators	N of studies	WMD/RR (95% CI)	p	I^2 (%)
Complications					
Abdominal distension	Overall	4	2.53 (1.17, 5.49)	0.019	0.0
	Sensitive analysis[a]	4	2.53 (1.17, 5.49)		
	Sensitive analysis[b]	3	2.47 (1.08, 5.63)		
	Sensitive analysis[c]	-	-		
Nausea/vomiting	Overall	5	2.01 (1.09, 3.71)	0.025	0.0
	Sensitive analysis[a]	5	2.01 (1.09, 3.71)		
	Sensitive analysis[b]	4	1.73 (0.86, 3.50)		
	Sensitive analysis[c]	4	2.72 (1.17, 6.33)		
Diarrhea	Overall	3	3.17 (1.41, 7.10)	0.005	0.0
	Sensitive analysis[a]	3	3.17 (1.41, 7.10)		
	Sensitive analysis[b]	2	3.04 (1.03, 9.03)		
	Sensitive analysis[c]	2	3.25 (1.13, 9.35)		
Incision infection	Overall	6	0.81 (0.45, 1.48)	0.501	0.0
	Sensitive analysis[a]	6	0.81 (0.45, 1.48)		
	Sensitive analysis[b]	5	0.73 (0.38, 1.42)		
	Sensitive analysis[c]	5	0.81 (0.41, 1.61)		
Anastomotic fistula	Overall	3	0.17 (0.02, 1.38)	0.097	0.0
	Sensitive analysis[a]	3	0.17 (0.02, 1.38)		
	Sensitive analysis[b]	2	0.17 (0.02, 1.38)		
	Sensitive analysis[c]	-	-		
Postoperative recovery					
Time to first flatus	Overall	6	0.80 (0.62, 0.98)	<0.001	96.1
	Sensitive analysis[a]	6	0.80 (0.62, 0.98)		
	Sensitive analysis[b]	5	0.65 (0.46, 0.85)		
	Sensitive analysis[c]	5	1.13 (0.92, 1.33)		
Time to first feces	Overall	4	1.86 (1.60, 2.11)	<0.001	96.6
	Sensitive analysis[a]	4	1.86 (1.60, 2.11)		
	Sensitive analysis[b]	3	1.65 (1.39, 1.92)		
	Sensitive analysis[c]	-	-		
Duration of hospital stay	Overall	5	0.56 (0.37, 0.75)	<0.001	91.4
	Sensitive analysis[a]	5	0.56 (0.37, 0.75)		
	Sensitive analysis[b]	4	0.49 (0.29, 0.70)		
	Sensitive analysis[c]	4	0.80 (0.58, 1.02)		
Nutritional indicators					
ALB (g/L)	Overall	6	-1.09 (-1.27, -0.91)	<0.001	93.5
	Sensitive analysis[a]	6	-1.09 (-1.27, -0.91)		
	Sensitive analysis[b]	5	-1.06 (-1.26, -0.87)		
	Sensitive analysis[c]	5	-1.40 (-1.61, -1.20)		

TABLE 3. Continued

Outcomes	Indicators	N of studies	WMD/RR (95% CI)	p	I^2 (%)
PA (mg/L)	Overall	5	-1.20 (-1.40, -0.99)	< 0.001	90.7
	Sensitive analysis[a]	5	-1.20 (-1.40, -0.99)		
	Sensitive analysis[b]	4	-1.13 (-1.34, -0.91)		
	Sensitive analysis[c]	-	-		
TF (g/L)	Overall	5	-0.60 (-0.79, -0.42)	<0.001	88.4
	Sensitive analysis[a]	5	-0.60 (-0.79, -0.42)		
	Sensitive analysis[b]	4	-0.45 (-0.65, -0.25)		
	Sensitive analysis[c]	4	-0.67 (-0.89, -0.45)		
HGB (g/L)	Overall	2	-0.76 (-1.09, -0.44)	<0.001	96.2
	Sensitive analysis[a]	2	-0.76 (-1.09, -0.44)		
	Sensitive analysis[b]	2	-0.76 (-1.09, -0.44)		
	Sensitive analysis[c]	-	-		
Immunological indicators					
$CD3^+$ (%)	Overall	3	-0.71 (-0.95, -0.47)	<0.001	90.7
	Sensitive analysis[a]	3	-0.71 (-0.95, -0.47)		
	Sensitive analysis[b]	2	-0.86 (-1.14, -0.58)		
	Sensitive analysis[c]	-	-		
$CD4^+$ (%)	Overall	3	-0.22 (-0.45, 0.01)	0.060	31.1
	Sensitive analysis[a]	3	-0.22 (-0.45, 0.01)		
	Sensitive analysis[b]	2	-0.21 (-0.47, 0.05)		
	Sensitive analysis[c]	-	-		
$CD4^+/CD8^+$ (%)	Overall	3	-0.84 (-1.08, -0.59)	<0.001	92.4
	Sensitive analysis[a]	3	-0.84 (-1.08, -0.59)		
	Sensitive analysis[b]	2	-1.06 (-1.34, -0.77)		
	Sensitive analysis[c]	-	-		

EN, enteral nutrition; PN, parenteral nutrition; N, number of samples; NA, not applicable; WMD, weighted mean difference; RR, relative risk; CI, confidence interval; ALB, albumin; PA, prealbumin; TF, transferrin; HGB, hemoglobin; IgA, immunoglobulin, IgG. immunoglobulin G; IgM, immunoglobulin M; $CD3^+$, cluster of differentiation 3; $CD4^+$, cluster of differentiation 4; $CD8^+$, cluster of differentiation 8. [a]Sensitivity analysis was conducted by leave-one-out approach; [b]Sensitivity analysis was conducted by removing smallest study; [c]Sensitivity analysis was conducted by removing study with highest risk of bias.

studies, the postoperative recovery, nutritional status, and immune function ($CD3^+$ level and $CD4^+/CD8^+$) were significantly better in the EN + PN group than in the EN or PN groups in our study. Previous studies have suggested that postoperative complications are lesser with EN than with PN.[32,33] In a comparative study of EN and PN in patients undergoing gastrectomy for gastric malignancy, Xin et al.[33] determined that the durations of postoperative fever and anal fatigue were longer with PN. In addition, they attributed the reduced postoperative fever duration in the EN group to a lower incidence of infection or enhanced immune system. In our study, there was no statistical difference in postoperative complications between the PN and PN + EN groups. However, the incidence of bloating, diarrhea, and vomiting was lower in the PN + EN group. This may be attributed to intestinal intolerance to EN.[15] Although there was no difference in postoperative complications between the EN + PN and PN groups in our study, EN + PN may be a crucial postoperative nutritional support in patients with gastrointestinal cancers due to its superiority in postoperative recovery, nutritional function, and immune function.

Although EN reportedly improves gastrointestinal function, it is usually associated with a higher risk of gastrointestinal intolerance, manifesting as vomiting and reflux[15,34] due to postoperative intestinal injury and elevated levels of inflammatory factors.[35] EN provides nutrients via the gastrointestinal tract, thereby maintaining the normal function and structure of the intestinal tract.[10] However,

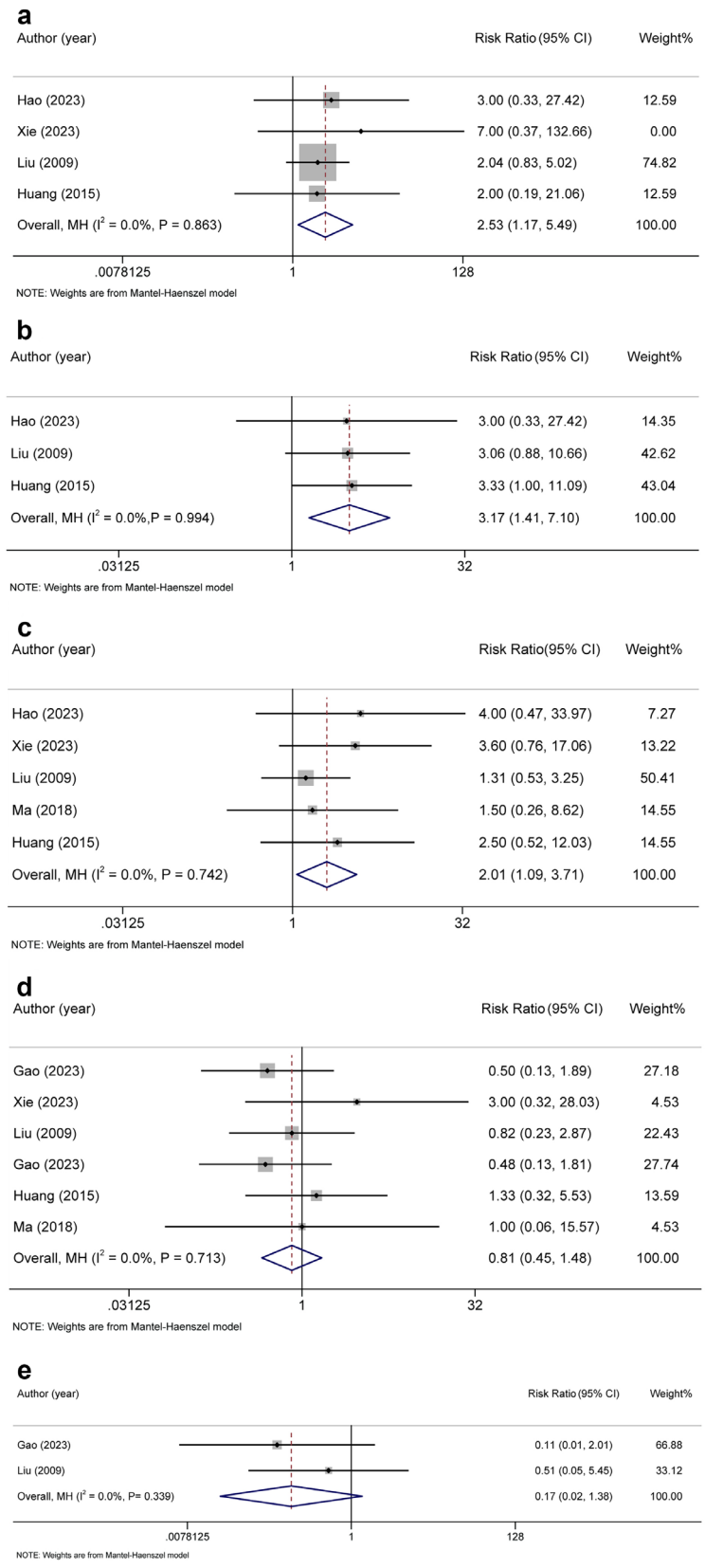

FIG. 3. Postoperative complication indicators in the EN and EN + PN groups: (a) abdominal distension, (b) diarrhea, (c) nausea/vomiting, (d) surgical wound infection, and (e) anastomotic fistula.

CI, confidence interval; EN, enteral nutrition, PN, parenteral nutrition.

PN provides nutrients directly via the vein, which can rapidly meet the nutritional needs of the patient.[12] Thus, the combined use of EN and PN can circumvent the potential deficiencies in nutrient intake that may arise from relying on a single route of supply.[36] The combination of EN and PN is thought to concurrently facilitate the delivery of nutrients and reduce the burden on the intestinal tract, thereby promoting the rapid recovery of intestinal function after surgery. Furthermore, EN can provide fiber and prebiotics, which promote the growth of beneficial bacteria and maintain the balance of intestinal microorganisms.[37,38] Specific essential nutrients, including amino acids (such as glutamine), fatty acids (such as omega-3 fatty acids), and micronutrients (such as zinc, vitamin E, and vitamin C), are vital for the immune system to function.[39] The PN solution usually includes lipid emulsions (LEs), complex amino acids, water-soluble vitamins, fat-soluble vitamins, glucose, electrolytes, and trace elements.[40] LEs are an important source of high-density energy, essential fatty acids, and fat-soluble vitamins,[41] while complex amino acids are crucial for tissue repair and physiological functions.[42] Better postoperative recovery usually results in a shorter hospital stay, whereas a slow recovery or development of complications may result in a longer hospital stay. In our study, the nutritional and immune function improved in the PN + EN group, which facilitated a better and faster postoperative recovery and shorter postoperative hospital stay. This finding highlights the critical role of postoperative nutritional support in patient recovery, and it may aid in reducing healthcare resource use and patient's financial burden.[43,44] When complete EN is not feasible immediately after surgery, PN can be an important source of nutrition. Subsequently, EN can be gradually introduced and eventually transitioned to the primary mode of nutritional support. This approach ensures that nutritional support is not delayed and that the gastrointestinal tract is not overburdened.

To the best of our knowledge, ours is the first meta-analysis to comprehensively evaluate the effects of postoperative EN, PN, and EN + PN in patients with gastrointestinal cancer. The study synthesized data from previous RCTs on postoperative nutritional support for gastrointestinal cancers. The study is a comprehensive comparison of two methods of nutritional support in the following four areas: postoperative recovery, nutrition, immunity, and complications. Our study results have significant clinical implications. First, the combination of EN + PN significantly facilitates patients' postoperative recovery by shortening the intestinal recovery phase and length of hospital stay. Second, the EN + PN protocol intensifies nutritional support to ensure that patients receive the necessary nutrients during the critical postoperative period, which helps to maintain or restore their physical functions. Third, the application of EN + PN strengthens the patient's immune system, which is essential to resist possible postoperative infections. Finally, by reducing the intolerance to EN, this protocol reduces the discomfort of patients, further optimizing their therapeutic experience. This study's findings present an important basis for the selection of appropriate nutritional support, allowing clinicians to consider different regimens for the personalization of treatments to the patient's needs. With further studies, physicians will be able to optimize nutritional support strategies more precisely, thereby providing patients with more effective and safer treatment options.

Our study has certain limitations. First, the sources of heterogeneity remain unclear. Heterogeneity may be attributed to factors such as patient age, disease characteristics, nutritional status, individual differences, and the specific nutritional supplement implemented (caloric content and ratios of protein, fat, and carbohydrate may vary between EN, PN, and EN + PN). A more in-depth subgroup analysis could not be performed due to the limited data available. A meta-regression analysis may better address the heterogeneity in large datasets in future studies. Thus, more clearly standardized studies are required to benefit the analysis. Second, although an extensive database search was performed, all the included studies had been conducted in China. In the future, more multicenter studies with larger sample sizes, more diverse population, and higher treatment should be conducted. Finally, due to insufficient data on each outcome, the publication bias could not be evaluated, which might impose certain constraints on the interpretation of our findings.

In conclusion, our study provides a comprehensive evaluation of the clinical efficacy and safety of three nutritional support therapies (EN, PN, EN + PN) administered postoperatively in patients with gastrointestinal cancer. Current evidence indicates that the combined EN + PN therapy significantly improves postoperative recovery, nutritional status, immune status, and complications in patients with gastrointestinal cancer than PN or PN alone. However, due to the quality of the included studies, our findings require further validation via larger sample-sized, higher quality RCTs to establish a valid clinical basis.

Acknowledgements: Thanks for the support from the Management Research Project of Changzhou Maternal and Child Health Hospital, and Nanjing Medical University Science and Technology Development Fund General Project.

Ethics Committee Approval: Not applicable.

Informed Consent: Not applicable.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Authorship Contributions: Concept- M.C., B.Y., L.D.; Design- M.C., B.Y., L.D.; Data Collection or Processing- M.C., B.Y., Y.Z.; Analysis and/or Interpretation- M.C., B.Y., Y.Z.; Writing- M.C., B.Y.; Critical Review- L.D.

Conflict of Interest: The authors declare that they have no conflict of interest.

Funding: This work was supported by the fund from the Management Research Project of Changzhou Maternal and Child Health Hospital in 2024 (no. GL202406), and Nanjing Medical University Science and Technology Development Fund General Project (no. NMUB20230060).

Supplementary Figure 1 and 2: https://www.balkanmedicaljournal.org/img/files/SUPLEMMENT%20FIGURE.pdf

Supplementary Table 1: https://www.balkanmedicaljournal.org/img/files/SUPLEMMENT%20TABLO.pdf

REFERENCES

1. Peery AF, Crockett SD, Murphy CC, et al. Burden and cost of gastrointestinal, liver, and pancreatic diseases in the United States: Update 2018. *Gastroenterology*. 2019;156:254-272. [CrossRef]
2. Wang S, Zheng R, Li J, et al. Global, regional, and national lifetime risks of developing and dying from gastrointestinal cancers in 185 countries: a population-based systematic analysis of GLOBOCAN. *Lancet Gastroenterol Hepatol.* 2024;9:229-237. [CrossRef]
3. Ma CJ, Wu JM, Tsai HL, et al. Prospective double-blind randomized study on the efficacy and safety of an n-3 fatty acid enriched intravenous fat emulsion in postsurgical gastric and colorectal cancer patients. *Nutr J.* 2015;14:9. [CrossRef]
4. Johnston FM, Beckman M. Updates on management of gastric cancer. *Curr Oncol Rep*. 2019;21:67. [CrossRef]
5. Wang HM, Wang TJ, Huang CS, et al. Nutritional Status and related factors in patients with gastric cancer after gastrectomy: a cross-sectional study. *Nutrients*. 2022;14:2634. [CrossRef]
6. Hiramatsu K, Shindoh J, Hanaoka Y, et al. Postoperative nutritional status is predictive of the survival outcomes in patients undergoing resection of stage III colorectal cancer. *World J Surg*. 2021;45:3198-3205. [CrossRef]
7. Kanda M. Preoperative predictors of postoperative complications after gastric cancer resection. *Surg Today.* 2020;50:3-11. [CrossRef]
8. Aotani N, Yasui-Yamada S, Kagiya N, et al. Malnutrition by European Society for Clinical Nutrition and Metabolism criteria predicts prognosis in patients with gastrointestinal and hepatobiliary-pancreatic cancer. *Clin Nutr ESPEN*. 2021;42:265-271. [CrossRef]
9. Lewis SR, Schofield-Robinson OJ, Alderson P, Smith AF. Enteral versus parenteral nutrition and enteral versus a combination of enteral and parenteral nutrition for adults in the intensive care unit. *Cochrane Database Syst Rev.* 2018;6:CD012276. [CrossRef]
10. Doley J. Enteral nutrition overview. *Nutrients*. 2022;14:2180. [CrossRef]
11. McClave SA, Omer E. Clinical nutrition for the gastroenterologist: the physiologic rationale for providing early nutritional therapy to the hospitalized patient. *Curr Opin Gastroenterol*. 2020;36:118-121. [CrossRef]
12. Ramiro-Cortijo D, Del Pozo Arribas S, Insterra Viu L, Vázquez NG, Saenz de Pipaon M. Exclusive fish oil lipid emulsion rescue strategy improves cholestasis in neonates on partially fish oil-based lipid emulsion: a pilot study. *Nutrients*. 2023;15:509. [CrossRef]
13. Deng G, Lei Q, Gao X, et al. Glucagon-like peptide-2 modulates enteric paneth cells immune response and alleviates gut inflammation during intravenous fluid infusion in mice with a central catheter. *Front Nutr.* 2021;8:688715. [CrossRef]
14. Sunario J, Wibrow B, Jacques A, Ho KM, Anstey M. Associations between nutrition markers and muscle mass on bioimpedance analysis in patients receiving parenteral nutrition. *JPEN J Parenter Enteral Nutr.* 2021;45:1089-1099. [CrossRef]
15. Heyland DK, Ortiz A, Stoppe C, et al. Incidence, risk factors, and clinical consequence of enteral feeding intolerance in the mechanically ventilated critically Ill: an analysis of a multicenter, multiyear database. *Crit Care Med*. 2021;49:49-59. [CrossRef]
16. Cederholm T, Barazzoni R, Austin P, et al. ESPEN guidelines on definitions and terminology of clinical nutrition. *Clin Nutr.* 2017;36:49-64. [CrossRef]
17. Thibault R, Makhlouf AM, Kossovsky MP, et al. Healthcare-associated infections are associated with insufficient dietary intake: an observational cross-sectional study. *PLoS One*. 2015;10:e0123695. [CrossRef]
18. Zeng HJ, Liu JJ, Yang YC. Clinical observation of gastrointestinal function recovery in patients after hepatobiliary surgery. *World J Gastrointest Surg*. 2024;16:76-84. [CrossRef]
19. Wang Y, Zheng J, Gao Z, Han X, Qiu F. Investigation on nutritional risk assessment and nutritional support status of surgical patients with colorectal cancer. *J BUON.* 2018;23:62-67. [CrossRef]
20. Wu W, Zhong M, Zhu DM, et al. Effect of early full-calorie nutrition support following esophagectomy: a randomized controlled trial. *JPEN J Parenter Enteral Nutr.* 2017;41:1146-1154. [CrossRef]
21. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. [CrossRef]
22. Cumpston M, Li T, Page MJ, et al. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. *Cochrane Database Syst Rev.* 2019;10:ED000142. [CrossRef]
23. Amir-Behghadami M, Janati A. Population, intervention, comparison, outcomes and study (PICOS) design as a framework to formulate eligibility criteria in systematic reviews. *Emerg Med J.* 2020;37:387. [CrossRef]
24. Higgins JP, Altman DG, Gøtzsche PC, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ*. 2011;343:d5928. [CrossRef]
25. Liu C, Li X, Wang S, Zhang M, Liu X. The application of early postoperative enteral nutrition combinded with parenteralnutriton in aged patients with gastric carcinoma. *Practical Clinical Medicine*. 2009;10:19-21. [CrossRef]
26. Liu A, Cai Y, Yuan Y, et al. Efficacy and safety of carnitine supplementation on NAFLD: a systematic review and meta-analysis. *Syst Rev*. 2023;12:74. [CrossRef]
27. Yan X, Zhou FX, Lan T, et al. Optimal postoperative nutrition support for patients with gastrointestinal malignancy: a systematic review and meta-analysis. *Clin Nutr*. 2017;36:710-721. [CrossRef]
28. Zhao XF, Wu N, Zhao GQ, Liu JF, Dai YF. Enteral nutrition versus parenteral nutrition after major abdominal surgery in patients with gastrointestinal cancer: a systematic review and meta-analysis. *J Investig Med*. 2016;64:1061-1074. [CrossRef]
29. Fan X, Xu Y, Wan R, Zhang L, Han H, Chen J. A clinical study on gastric cancer patients administered EN and PN versus PN alone in enhanced recovery after surgery. *Ann Med Surg (Lond).* 2024;86:1433-1440. [CrossRef]
30. Seo JM, Joshi R, Chaudhary A, et al. A multinational observational study of clinical nutrition practice in patients undergoing major gastrointestinal surgery: The Nutrition Insights Day. *Clin Nutr ESPEN*. 2021;41:254-260. [CrossRef]
31. Zhang X, Hu Y, K. L. Enteral combined with parenteral nutrition and enteral nutrition alone in postoperative patients with gastric cancer: a meta-analysis. Chinese Journal of Evidence-Based Medicine. 2022;22:60-66. [CrossRef]
32. Berlana D. Parenteral nutrition overview. *Nutrients*. 2022;14:4480. [CrossRef]
33. Xin F, Mzee SAS, Botwe G, et al. Short-term evaluation of immune levels and nutritional values of EN versus PN in gastric cancer: a systematic review and a meta-analysis. *World J Surg Oncol*. 2019;17:114. [CrossRef]
34. Gungabissoon U, Hacquoil K, Bains C, et al. Prevalence, risk factors, clinical consequences, and treatment of enteral feed intolerance during critical illness. *JPEN J Parenter Enteral Nutr.* 2015;39:441-448. [CrossRef]
35. An S, Kim K, Kim MH, Jung JH, Kim Y. Perioperative probiotics application for preventing postoperative complications in patients with colorectal cancer: a systematic review and meta-analysis. *Medicina (Kaunas)*. 2022;58:1644. [CrossRef]
36. Hill A, Heyland DK, Elke G, et al. Meeting nutritional targets of critically ill patients by combined enteral and parenteral nutrition: review and rationale for the EFFORTcombo trial. *Nutr Res Rev.* 2020;33:312-320. [CrossRef]
37. Huang Z, Wang Y. Perioperative enteral immunonutrition with probiotics favors the nutritional, inflammatory, and functional statuses in digestive system surgery. *Asia Pac J Clin Nutr*. 2022;31:78-86. [CrossRef]
38. Xu R, Ding Z, Zhao P, Tang L, Tang X, Xiao S. The effects of early post-operative soluble dietary fiber enteral nutrition for colon cancer. *Nutrients*. 2016;8:584. [CrossRef]
39. Shakoor H, Feehan J, Al Dhaheri AS, et al. Immune-boosting role of vitamins D, C, E, zinc, selenium and omega-3 fatty acids: Could they help against COVID-19? *Maturitas*. 2021;143:1-9. [CrossRef]
40. Li JH, Han L, Du TP, Guo MJ. The effect of low-nitrogen and low-calorie parenteral nutrition combined with enteral nutrition on inflammatory cytokines and immune functions in patients with gastric cancer: a double blind placebo trial. *Eur Rev Med Pharmacol Sci*. 2015;19:1345-1350. [CrossRef]
41. Hartman C, Shamir R. Intravenous lipid emulsions in term infants: impact on laboratory and clinical outcomes and long-term consequences. *World Rev Nutr Diet.* 2015;112:81-9. [CrossRef]
42. Xiao F, Guo F. Impacts of essential amino acids on energy balance. *Mol Metab.* 2022;57:101393. [CrossRef]
43. Shang R, Han X, Zeng C, et al. Colonic stent as a bridge to surgery versus emergency rection for malignant left-sided colorectal obstruction: A systematic review and meta-analysis of randomized controlled trials. *Medicine (Baltimore).* 2023;102:e36078. [CrossRef]
44. Tevis SE, Kennedy GD. Postoperative complications: looking forward to a safer future. *Clin Colon Rectal Surg.* 2016;29:246-252. [CrossRef]