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Naso-intestinal versus gastric tube for enteral nutrition in patients undergoing mechanical ventilation: a systematic review and meta-analysis

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Abstract

Background A systematic appraisal of the comparative efficacy and safety profiles of naso-intestinal tube versus gastric tube feeding in the context of enteral nutrition for mechanically ventilated (MV) patients is imperative. Such an evaluation is essential to inform clinical practice, ensuring that the chosen method of nutritional support is both optimal and safe for this patient population.

Methods We executed an exhaustive search across PubMed et al. databases to identify randomized controlled trials (RCTs) that scrutinize the role of naso-intestinal and gastric tubes for mechanically ventilated (MV) patients up to May 30, 2024. The process of study selection, quality assessment, and data extraction was conducted independently by two researchers. RevMan 5.3 software was used for meta-analysis.

Results Our meta-analysis included 8 RCTs, published between 1992 and 2018, encompassing a total of 676 MV patients. The results indicated that naso-intestinal tube feeding, compared to gastric tube feeding, was associated with a significant reduction in the incidence of ventilator-associated pneumonia (VAP) [Risk Ratio (RR) = 0.69, 95% confidence interval (CI) (0.52, 0.92)] and gastric retention (RR = 0.11, 95% CI (0.04, 0.28)). No statistically significant differences were observed in the incidence of aspiration (RR = 0.93, 95% CI (0.35, 2.50)) vomiting (RR = 0.70, 95% CI (0.23, 2.08)), abdominal distension (RR = 0.87, 95% CI (0.29, 2.63)), or diarrhea (RR = 1.10, 95% CI (0.77, 1.55)).

Conclusions The current evidence indicates that naso-intestinal tube feeding is efficacious in lowering the incidence of VAP and gastric retention among MV patients, without a corresponding escalation in the risk of adverse events, including aspiration, vomiting, abdominal distension, and diarrhea. These insights significantly augment the existing corpus of knowledge pertaining to the optimization of enteral nutrition strategies for patients on mechanical ventilation.

Keywords Naso-intestinal tube, Gastric tube, Enteral nutrition, Mechanical ventilation, Care, Nursing, Treatment

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Background

Ventilator-associated pneumonia (VAP) is a pulmonary infection that occurs 48 h after mechanical ventilation (MV), or within 48 h of extubation [1]. At present, the morbidity and mortality of VAP are relatively high, it's been reported that the incidence of VAP is 6 ~ 52%, and the mortality rate is 14 ~ 50% [2, 3]. Patients on MV frequently exhibit varying levels of consciousness impairment, precluding the ability to consume food autonomously. Concurrently, these individuals are often in a state of pronounced hypermetabolism, characterized by an elevated metabolic rate that can significantly impact their nutritional status and overall health [4, 5]. It has been reported that the provision of timely and adequate nutritional support, with a particular emphasis on enteral nutrition, is crucial for sustaining metabolic homeostasis, bolstering immune function, and mitigating the risk of pulmonary infections [6–8]. Therefore, enteral nutrition management is very important for the prognosis of MV patients.

At present, the commonly used clinical tube feeding methods for enteral nutrition are gastric tube and naso-intestinal tube feeding [9]. Indwelling gastric tube is one of the basic nursing operation techniques used in surgical gastrointestinal or acute abdominal surgery [10]. It is widely used in clinical practice, but the incidence of reflux and aspiration of gastric contents in patients is also high, which is up to 88.9% [11]. It's been reported that trans-gastric tube enteral nutrition is an independent risk factor for VAP in intensive care unit (ICU) patients [12, 13]. The shorter the time the indwelling gastric tube is in place, the lower the incidence of VAP [14]. Naso-intestinal tube placement refers to the method of indirect or direct delivery of the naso-intestinal tube into the duodenum or upper jejunum [15]. In comparison to gastric tube feeding, the placement of naso-intestinal tubes is associated with a diminished risk of aspiration and a lower incidence of VAP. Furthermore, this approach has been demonstrated to ameliorate the nutritional indices of patients requiring mechanical ventilation, concurrently reducing the duration of mechanical ventilation and the frequency of intensive care unit (ICU) admissions [16, 17]. Nevertheless, previous studies [18, 19] have highlighted that in critically ill patients with modestly elevated gastric residual volumes, naso-intestinal enteral nutrition may confer benefits such as a reduced incidence of ventilator-associated pneumonia (VAP) and enhanced caloric intake. However, it also raises concerns regarding the potential for increased gastrointestinal bleeding risk. The efficacy and safety of naso-intestinal versus gastric tubes for enteral nutrition in MV patients are subjects of ongoing debate, with existing literature presenting conflicting findings. In light of this, the objective of the present study is to systematically assess the comparative effectiveness and safety of enteral nutrition delivered through naso-intestinal and gastric tubes in MV patients. Our aim is to contribute robust evidence to inform clinical decision-making and enhance the management and nursing practices associated with enteral nutrition in the context of mechanical ventilation.

Methods

We performed and reported this systematic review and meta-analysis in compliance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [20].

Inclusion and exclusion criteria

The inclusion criteria for this meta-analysis were ① study population: adult MV patients age ≥ 18 years old; ② intervention: the experimental group received naso-intestinal enteral nutrition, and the control group received nasogastric enteral nutrition; ③ study type: randomized controlled trial (RCT) design reported in English or Chinese; outcome indicators: the main outcome indicators included the incidence of VAP, aspiration, gastric retention, vomiting, abdominal distention and diarrhea. The exclusion criteria for this meta-analysis were ① the included patients received gastrostomy and intestinal fistula treatment; ② the relevant research data or the full text of the research could not be obtained.

Research strategy

We used a combination of free words and subject terms to search CINAHL, PubMed, the Cochrane Library, Web of Science, British Nursing Index, Wanfang, and China National Knowledge Infrastructure (CNKI) databases for related reports on the effectiveness and safety of the naso-intestinal tube and gastric tube application in MV patients. The search strategy utilized in this meta-analysis was as delineated below: ("mechanical ventilation" OR "mechanically ventilated" OR "ventilation" OR "artificial airway") AND ("nasoenteral tube" OR "gastrointestinal feed" OR "nasogastric tube" OR "nasogastric feed" OR "nasointestinal" OR "enteral nutrition"). We searched the clinical trial database (Clinical Trials.gov) for unpublished publications on the effectiveness and safety of the application of naso-intestinal tubes and gastrointestinal nutrition in MV patients. The search language of this meta-analysis was not limited, and the search time limit was from the establishment of the database to May 30, 2024. In the execution of this meta-analysis, a meticulous literature search was performed by two researchers who adhered to the search strategy. This approach was meticulously designed to uphold the highest standards of methodological rigor and to ensure the precision and

accuracy of the search process. At the same time, we reviewed and searched the references of identified RCTs and associated reviews to avoid missed report detection.

Literature screening and data extraction

Two researchers independently screened the literature according to the inclusion and exclusion criteria of the literature. Disparities regarding the inclusion of literature in this meta-analysis were amicably resolved through collaborative deliberation between the two researchers. In instances where consensus could not be reached following initial discussions, the matter was escalated to include the input of a third researcher, thereby facilitating a more comprehensive and objective resolution. Data extraction was performed by two researchers independently extracting the data and information included in the study based on the pre-designed literature data extraction table. After extraction, the two researchers reviewed the data with each other. After the literature screening is completed, the data would be extracted, and for the studies with the lack of data, we would contact the corresponding author for more data. The data extracted in this meta-analysis included the research area, sample size, basic data of the study population, intervention measures, and outcome indicators.

Risk of bias evaluation

Two researchers conducted an independent assessment and grading of the methodological quality of the RCTs included in this study, adhering to the evaluation criteria outlined in the Cochrane Evaluation Manual 5.1.0 [21]. The assessment encompassed various aspects, including the generation of random sequences, concealment of allocation, blinding of participants and researchers, outcome assessor blinding, completeness of outcome data, potential for selective reporting, and the presence of other biases. Each criterion was evaluated and categorized as presenting a "high risk of bias," "low risk of bias," or being "unclear."

Statistical method

We used ReVman5.3 software to perform a meta-analysis. We used risk ratio (RR) and 95% confidence interval (CI) for dichotomous outcomes. We have applied both random effects and fixed effects models to all our results. The presence of publication bias was meticulously assessed through the utilization of funnel plots, with the degree of asymmetry therein quantitatively evaluated via the execution of an Egger regression analysis. To ascertain the robustness of the research findings, a sensitivity analysis was meticulously conducted by sequentially excluding individual research datasets, thereby scrutinizing the stability of the resultant outcomes. $P<0.05$ indicated that the difference was statistically significant.

Results

Study selection

As presented in Fig. 1, we initially identified the 155 potentially relevant studies in the first search. Of these identified articles, 18 studies were excluded as duplicates. After reviewing the titles and abstracts of the 137 remaining studies, the full texts of 56 studies were retrieved. Among them, 48 studies were excluded for failure to meet the inclusion criteria. Finally, 8 RCTs were included in this present meta-analysis [22–29].

The characteristics and quality of included RCTs

Of the 8 included RCTs [22–29], a total of 676 MV patients were included, specifically with 329 patients receiving the naso-intestinal tube treatment, and 347 patients receiving the gastric tube treatment. The included studies were reported from Spain, China, Brazil, Canada, USA and Australia. The average age of the patients enrolled in the included studies was about 55 years old, and there were more male patients than female patients. Most studies have reported the patient's APACHE II score, and VAP is the most commonly reported result of each study. The characteristics of included RCTs are indicated in Table 1.

The quality of included RCTs is presented in Figs. 2 and 3. In this systematic review, all RCTs claimed to implement randomization, and they offered a comprehensive description of the methods used for generating randomization sequences. However, only a single RCT within our dataset explicitly documented the process of allocation concealment, which is a critical component of trial design to prevent selection bias. Moreover, none of the studies provided specific information regarding blinding procedures, such as the methods employed to mask the intervention allocation from both participants and researchers, which could potentially introduce performance and detection biases. Upon meticulous review, we found no evidence of selective reporting or other significant biases within the eight RCTs that were included in this systematic review.

Meta-analysis

The incidence of VAP

Six RCTs reported the incidence of VAP [22–27]. The statistical heterogeneity among the studies was small ($P=0.13$, $I^2=41\%$), and the fixed effects model was used for analysis. Meta-analysis showed that compared with gastric tube feeding, naso-intestinal tube feeding was beneficial in reducing the incidence of VAP in MV

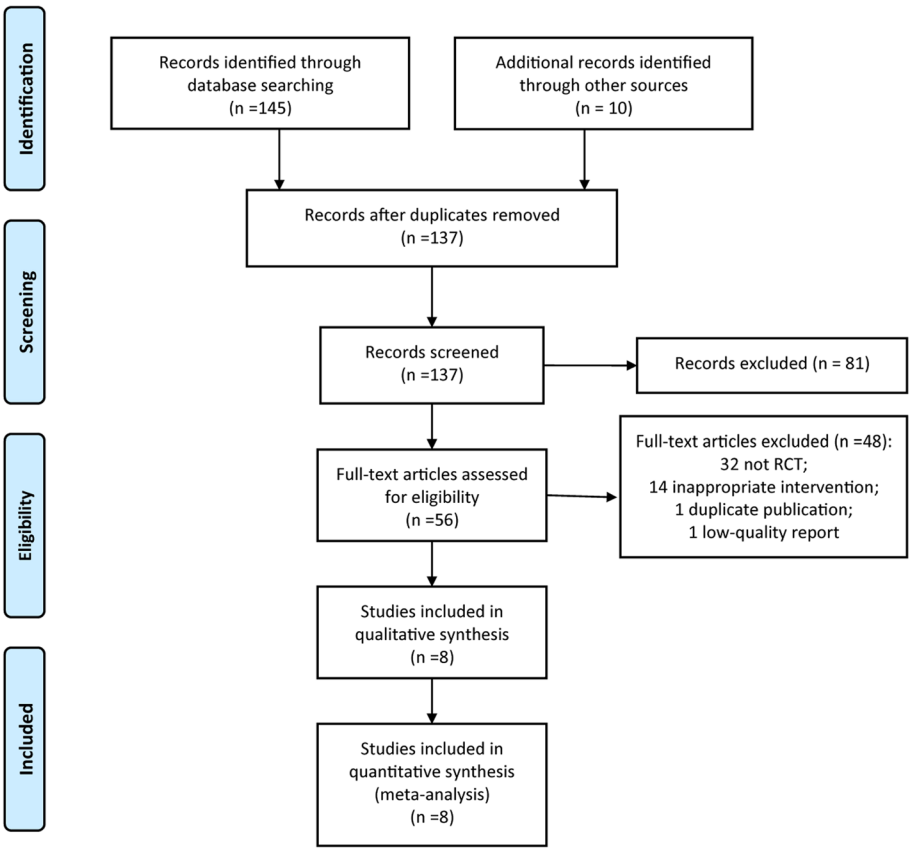

Fig. 1 PRISMA flow diagram of study selection

patients [RR = 0.69, 95%CI (0.52, 0.92), $P = 0.01$], see Fig. 4A.

The incidence of aspiration

Three studies reported the number of people with aspiration [22, 24, 29]. The statistical heterogeneity among the studies was small ($P = 0.33$, $I^2 = 9\%$), and the fixed effects model was used for analysis. The results of the meta-analysis showed that there was no statistically significant difference in the incidence of aspiration between the naso-intestinal tube and gastric tube feeding [RR = 0.93, 95%CI (0.35, 2.50), $P = 0.88$], see Fig. 4B.

Incidence of abdominal distention

Two studies reported the number of people with abdominal distension [22, 26]. The statistical heterogeneity between the studies was small ($P = 0.28$, $I^2 = 15\%$), and the fixed-effects model was used for meta-analysis. The results of the meta-analysis showed that the incidence of abdominal distension between the naso-intestinal tube and gastric tube feeding was not statistically different [RR = 0.87, 95%CI (0.29, 2.63), $P = 0.81$], see Fig. 4C.

The incidence of gastric retention Three studies reported the number of people with gastric retention [22, 25, 26]. The statistical heterogeneity among the studies was small ($P = 0.32$, $I^2 = 13\%$), and the fixed-effects model was used for analysis. Meta-analysis results showed that compared with gastric tube feeding, naso-intestinal tube feeding could reduce the incidence of gastric retention [RR = 0.11, 95%CI (0.04, 0.28), $P < 0.001$], see Fig. 5A.

The incidence of vomiting

Four studies reported the number of people for vomiting [23, 25–27]. The statistical heterogeneity among the studies was large ($P = 0.04$, $I^2 = 63\%$), and the random effects model was used for analysis. The results of the meta-analysis showed that there was no statistically significant difference in the incidence of vomiting between the naso-intestinal tube and gastric tube feeding [RR = 0.70, 95%CI (0.23, 2.08), $P = 0.52$], see Fig. 5B.

The incidence of diarrhea

Five studies reported the number of people with diarrhea [22, 23, 25–27]. The statistical heterogeneity among the studies was small ($P = 0.53$, $I^2 = 0\%$), and the fixed effects

Table 1 The characteristics of included RCTs

Study ID	Country	Sample size		Age		Male/female		APACHE II		Methods of administering enteral nutrition	Time of outcome assessment	Outcomes
		Naso-intestinal tube	Gastric tube	Naso-intestinal tube	Gastric tube	Naso-intestinal tube	Gastric tube	Naso-intestinal tube	Gastric tube			
Acosta 2010 [22]	Spain	50	54	35 ± 17	41 ± 20	44/6	46/8	16 ± 4	18 ± 5	Bolus feeding	Out of ICU	VAP; aspiration; gastric retention; abdominal distention; diarrhea
Ding 2018 [29]	China	50	50	48.11 ± 13.09	48.17 ± 14.66	31/19	30/20	16.59 ± 4.81	16.75 ± 4.14	Continuous feeding	Discharge from hospital	aspiration; abdominal distention; diarrhea
Friedman 2015 [23]	Brazil	54	61	63 ± 17	60 ± 14	30/24	26/35	22 ± 7	22 ± 6	Bolus feeding	Out of ICU	VAP; vomiting; diarrhea
Kearns 2000 [24]	Canada	21	23	54 ± 3	49 ± 4	14/7	16/7	22 ± 2	20 ± 1	Bolus feeding	Out of ICU	VAP; aspiration; daily calorie intake
Montecalvo 1992 [25]	USA	19	19	51 ± 22	45 ± 16	10/9	13/6	NA	NA	Bolus feeding	Discharge from hospital	VAP; gastric retention; vomiting;
Montejo 2002 [26]	Spain	50	51	57 ± 17	59 ± 18	36/14	35/16	18 ± 6	19 ± 7	Continuous feeding	Discharge from hospital	VAP; vomiting gastric retention
Wan 2015 [27]	China	35	35	19 ~ 88	23 ~ 91	23/12	25/10	NA	NA	Bolus feeding	Out of ICU	VAP; aspiration; gastric retention; diarrhea;
White 2009 [28]	Australia	50	54	50(45 ~ 70)	54(40 ~ 63)	24/26	28/26	30(25 ~ 35)	24.5 (20 ~ 28)	Bolus feeding	Out of ICU	Time to reach target nutrient

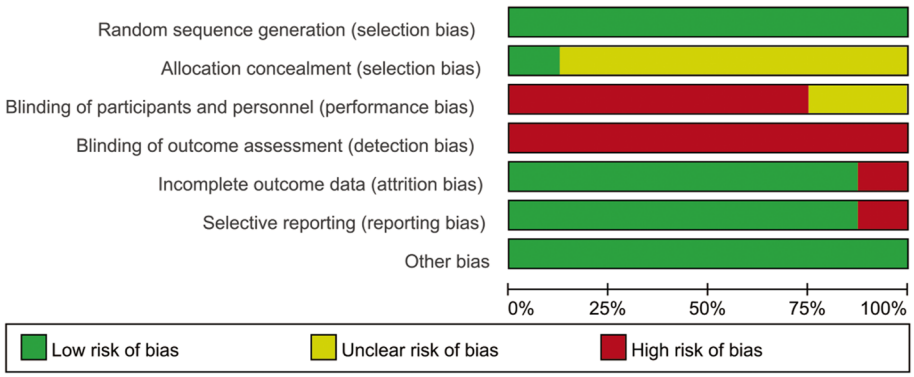

Fig. 2 Risk of bias graph

model was used for analysis. The results of the meta-analysis showed that there was no statistically significant difference in the incidence of diarrhea between the naso-intestinal tube and gastric tube feeding [RR = 1.10, 95%CI (0.77, 1.55), $P = 0.61$], see Fig. 5C.

We have employed both random effects and fixed effects models in our analysis and observed no significant alterations in the statistical outcomes. Furthermore, to conduct a sensitivity analysis for various clinical outcome indicators, we sequentially excluded individual research datasets. The results of this sensitivity analysis consistently demonstrated that the overall effects were robust and stable.

Publication bias

In our endeavor to assess publication bias, we employed funnel plots for visual representation, as depicted in Fig. 6. The symmetrical distribution of the plotted points within the funnel plots suggested a relatively uniform dispersion, indicative of a low likelihood of publication bias. This inference was further corroborated by the results of the Egger regression tests, where no significant evidence of publication bias was observed (all $P > 0.05$).

Discussions

Enteral nutrition support through the nasogastric tube plays an important role in clinical treatment. A nasogastric tube has been used to reduce the blood pressure of the gastrointestinal tract and drain the gastric contents for relevant judgment and analysis [30, 31]. Currently, the practice of indwelling nasogastric tube feeding stands as a pivotal therapeutic intervention for patients afflicted with coma or compromised swallowing function [32]. In the context of patients with MV, and particularly for those who are undergoing gastric-related surgical procedures, the occurrence of gastrointestinal complications, including gastric ulceration, gastric retention, and gastroesophageal reflux, is likely to exert a significant influence on the digestive capabilities of the stomach and may attenuate intestinal function. This underscores the importance of vigilant monitoring and management of these conditions to mitigate their impact on the overall gastrointestinal health of the patients [33]. Long-term feeding causes complications such as vocal cord paralysis, which may further worsen the condition [34, 35]. The results of this meta-analysis have shown that compared with gastric tube enteral nutrition, naso-intestinal enteral nutrition is beneficial in reducing the incidence of VAP and gastric retention in MV patients, and it does not increase the incidence of aspiration, vomiting, abdominal distension, and diarrhea.

VAP represents the most prevalent and perilous nosocomial infection encountered by patients on MV. The onset of VAP has been associated with a range of detrimental outcomes, including the prolongation of ventilator dependency, an extended duration of hospital stays, and an escalation in the incidence of complications. These factors collectively contribute to the heightened morbidity and mortality associated with VAP, underscoring the imperative for stringent preventive measures and timely therapeutic interventions [36]. The results of this study suggest that enteral nutrition via naso-intestinal tube can reduce the incidence of VAP in MV patients, while previous studies have shown that there is no statistically significant difference in the incidence of pneumonia in critically ill patients [37, 38]. The observed discrepancies may stem from the inclusion of patients in the study who have not been subjected to MV, whereas the study's population exclusively comprises MV patients. Additionally, the variability in diagnostic criteria for ventilator-associated pneumonia VAP could contribute to these inconsistencies. Patients on MV are particularly susceptible to gastroesophageal reflux and aspiration events, which can be attributed to the diminished capacity of the esophagus to clear refluxed contents and the frequent administration of substantial

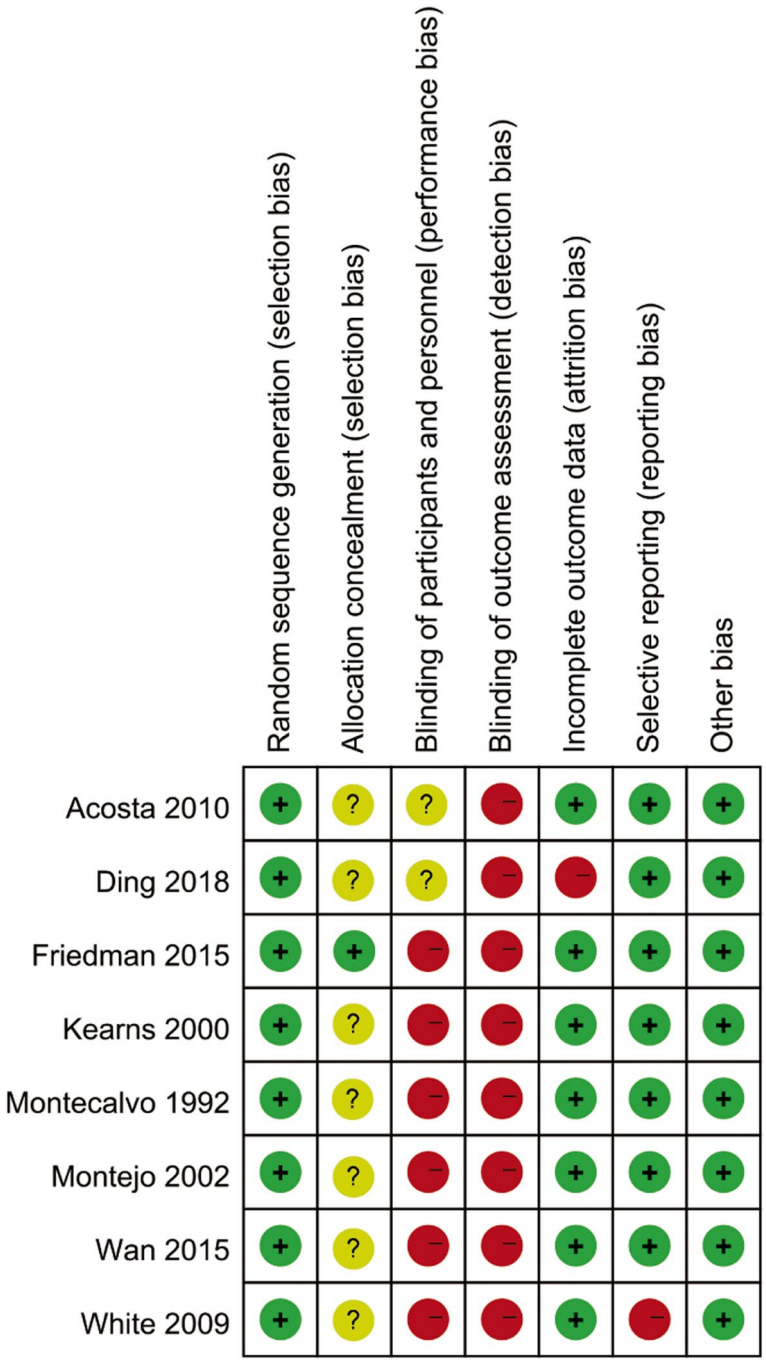

Fig. 3 Risk of bias summary

sedative doses [39]. Gastric reflux and aspiration are recognized as significant etiological factors in the development of VAP. Furthermore, the assessment of a patient's gastrointestinal motility and tolerance to enteral nutrition is of paramount importance [40]. Monitoring residual gastric volume serves as a critical tool in evaluating the risk of reflux, aspiration, and consequently, VAP. This approach facilitates a more nuanced understanding of the patient's condition and allows for the implementation of targeted interventions to mitigate the risk of these complications.

The results of this study show that enteral nutrition via naso-intestinal tube can reduce the incidence of gastric retention. Previous studies have pointed out

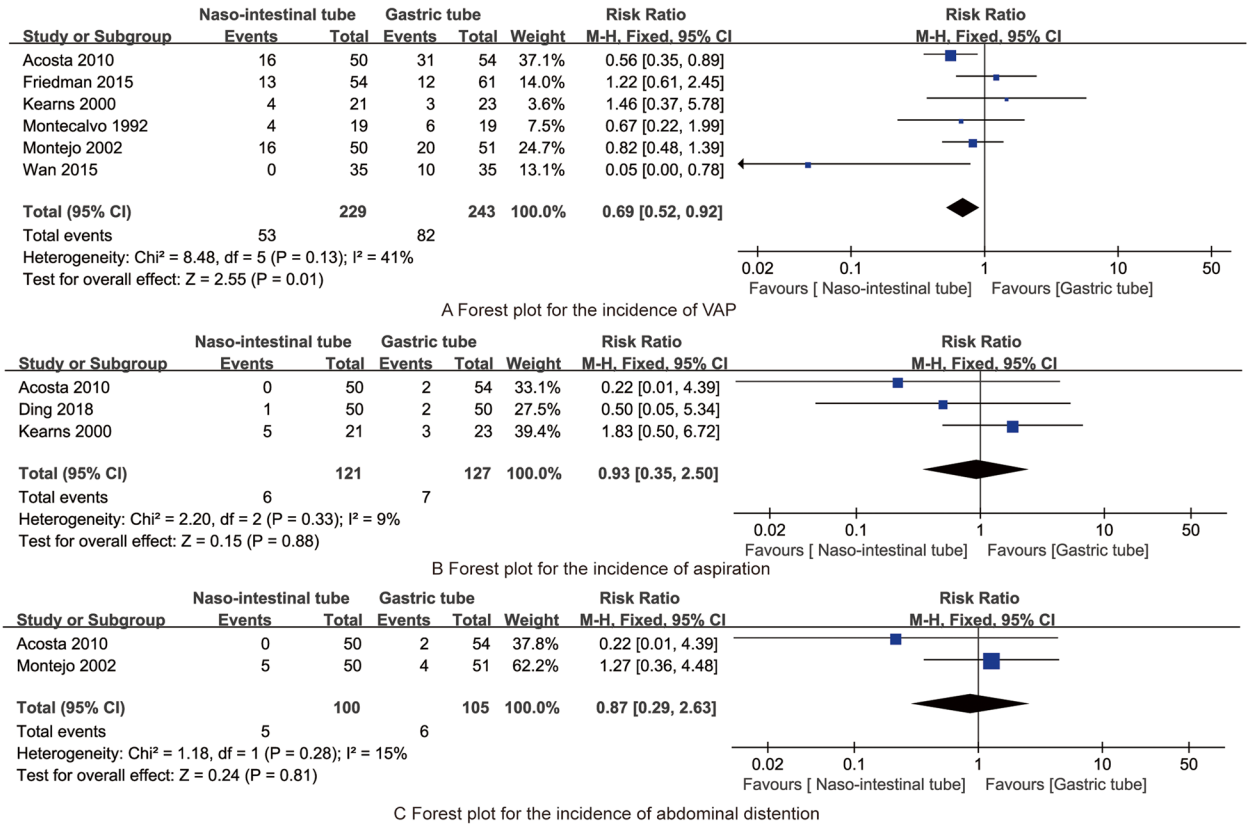

Fig. 4 The forest plots for synthesized outcomes of included RCTs

that naso-intestinal enteral nutrition is particularly suitable for critically ill patients with low Glasgow scores and a high risk of gastric retention [41, 42]. However, the absence of standardized diagnostic criteria for gastric retention across the studies under review has led to a wide range of reported critical values for gastric residual volume, spanning from 100 to 500 mL. The literature is notably sparse in terms of studies that directly compare the impact of the two enteral nutrition modalities on gastric retention in patients undergoing MV. Consequently, the findings in this area require further substantiation through additional empirical evidence in future research endeavors. This will be essential to establish more definitive guidelines and to enhance clinical decision-making regarding the management of gastric retention in the context of MV. Given the precarious health status of MV patients, who frequently exhibit impaired consciousness and dysphagia, their overall nutritional status tends to be compromised [10, 43, 44]. The body is in a state of high metabolism and high decomposition of negative nitrogen balance for a long time, and adequate nutritional support is required to reduce the occurrence of complications and improve the prognosis [45, 46]. It has been reported that the daily calorie intake of critically ill patients through enteral nutrition only reaches 50% to 64% of the target calories [47]. In critically ill patients requiring MV, inadequate nutritional intake is associated with an increased likelihood of prolonged ICU stays and extended durations of mechanical ventilation. This scenario can exacerbate the patient's condition, thereby heightening the susceptibility to complications, including the development of infections. The ramifications of suboptimal nutrition are far-reaching, emphasizing the critical importance of ensuring adequate nutritional support as a cornerstone of care in this vulnerable patient population [48]. Studies [49, 50] have shown that the incidence of aspiration in critically ill patients is 6.67 ~ 19.78%, and the incidence of diarrhea is 6.67 ~ 28.57%. The results of this study show that there is no significant difference in the incidence of aspiration, vomiting, abdominal distension, and diarrhea between naso-intestinal and gastric enteral nutrition, indicating that naso-intestinal enteral nutrition may not increase the incidence of the above complications in MV patients and it has a certain degree of safety [51].

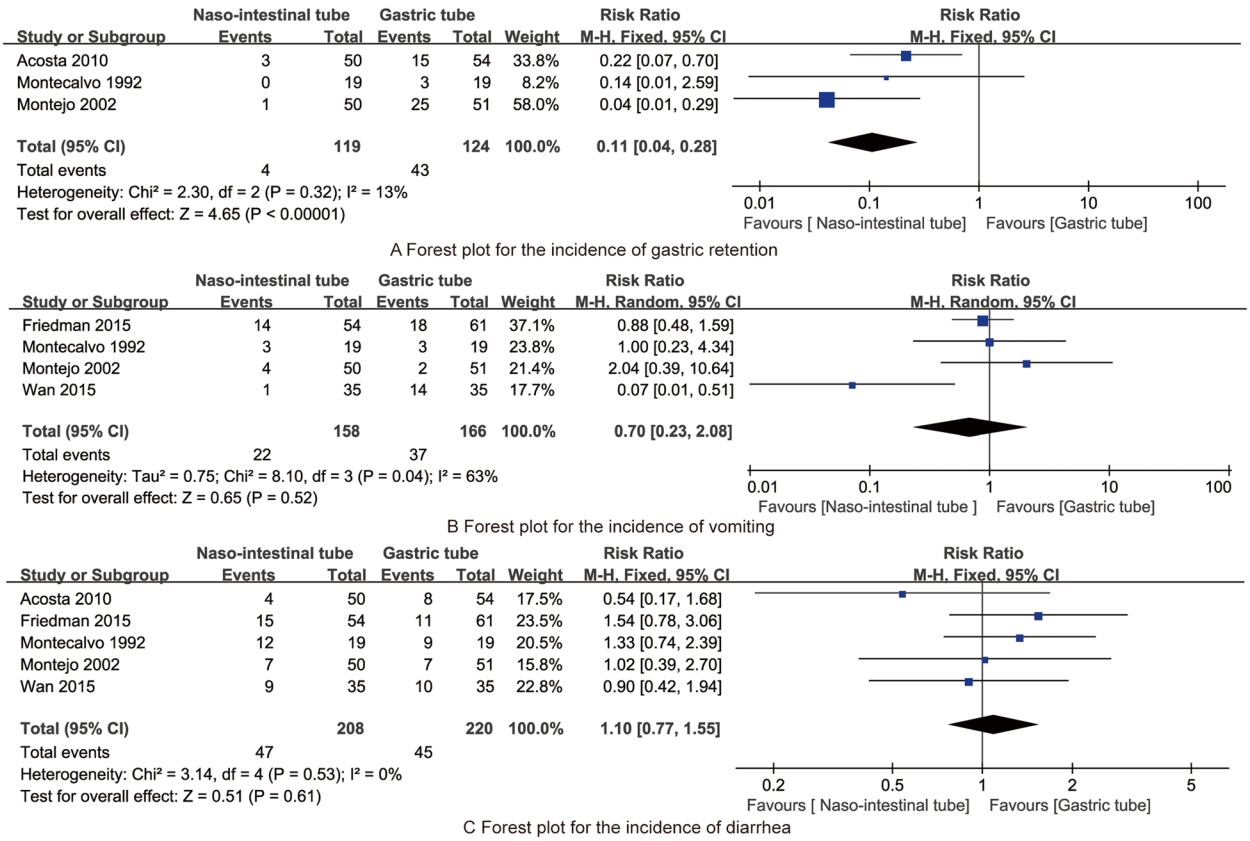

Fig. 5 The forest plots for synthesized outcomes of included RCTs

This meta-analysis has certain limitations that should be considered. Firstly, although all the studies included in our analysis are RCTs, a subset of these studies failed to detail the methods of random sequence generation and allocation concealment. Given the inherent nature of the interventional measures, the majority of the studies did not implement blinding of either the research participants or the investigators. Secondly, the diagnostic criteria of clinical outcome indicators in the included studies were not uniform, and some studies did not clearly report the specific diagnostic criteria, body position, and the risk for aspiration, which might have a certain impact on the judgment of the results. Additionally, the methodologies utilized for outcome assessment in some of the included RCTs are not explicitly detailed. Certain clinical outcome measures, including aspiration, abdominal distension, and daily caloric intake, were only reported in two RCTs each. Due to the constraints imposed by the available data, we were unable to conduct subgroup analyses or meta-regression to ascertain the sources of heterogeneity. Furthermore, the scope of our literature search was confined to studies published in English and Chinese, precluding the inclusion of research reported in other languages within this meta-analysis. Our study encompasses RCTs from Europe and the United States, where race is often considered a significant factor. However, due to limitations in the reported data, we were unable to perform subgroup analyses based on racial demographics. Hence, the potential of naso-intestinal tubes to facilitate earlier attainment of targeted nutritional goals and to enhance overall caloric intake merits further investigation in future studies. This inquiry will be pivotal in elucidating the comparative advantages and clinical implications of naso-intestinal tube feeding in the context of enteral nutrition support.

Conclusions

In conclusion, the findings of this study have revealed that enteral nutrition administered through naso-intestinal tubes is associated with a reduced incidence of VAP and gastric retention in patients on mechanical ventilation MV. Furthermore, this method of nutrition delivery has been shown to enhance patient nutritional intake without a concomitant increase in the prevalence of adverse events such as aspiration, vomiting, abdominal distension, and diarrhea. For MV patients who exhibit a

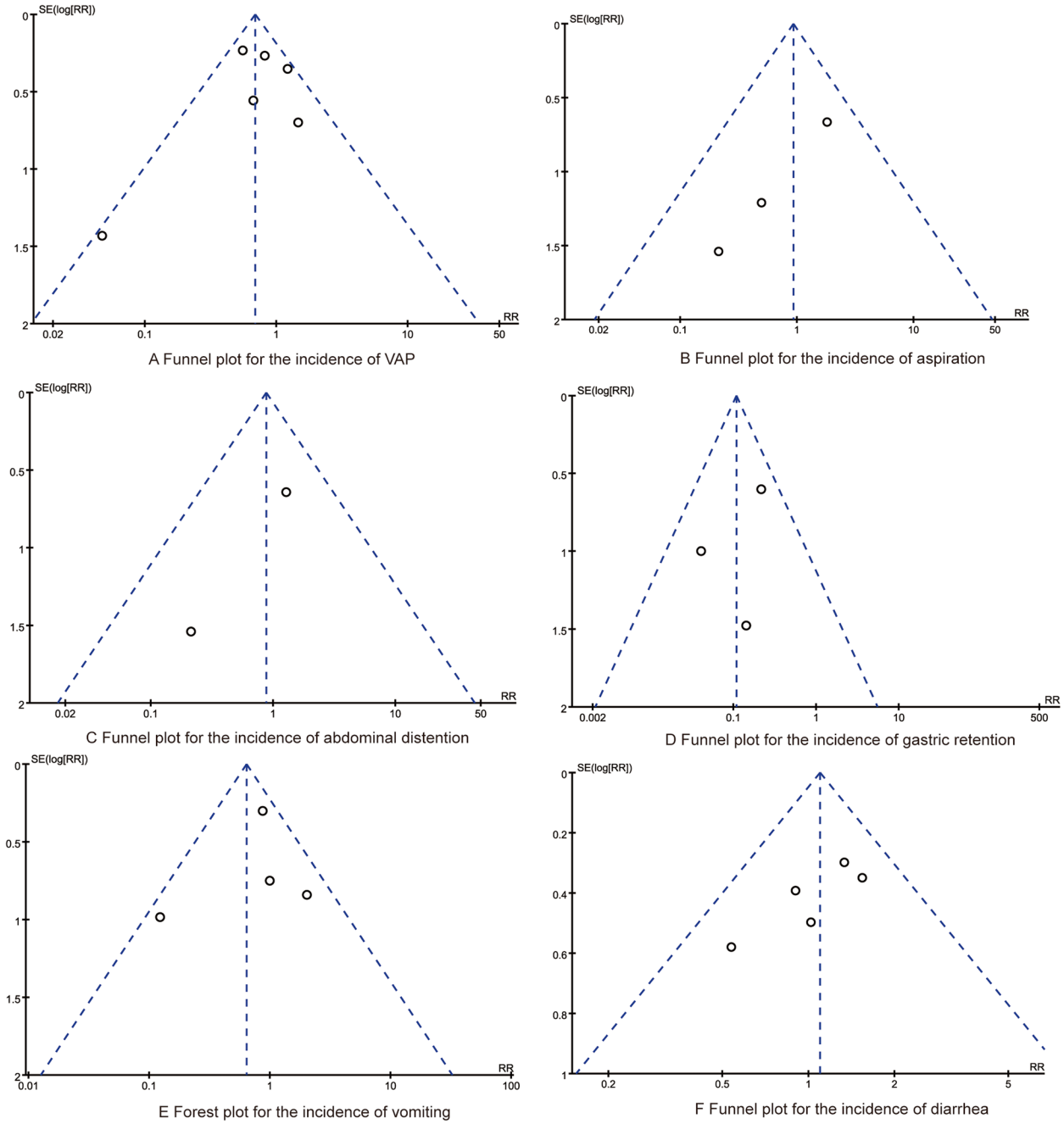

Fig. 6 The funnel plots for synthesized outcomes of included RCTs

predisposition to gastric retention, the use of naso-intestinal tubes for enteral nutrition may be a viable consideration. It is anticipated that future studies will conduct more comprehensive comparative analyses of the clinical efficacy of various enteral nutrition approaches in MV patients. Such research will be instrumental in furnishing a robust evidence base to inform clinical practice, guiding the selection of the most efficacious tube feeding strategies aimed at preventing or mitigating the complications associated with enteral nutrition.

Abbreviations

MV Mechanical ventilation
RCT Randomized controlled trial
VAP Ventilator-associated pneumonia

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None.

Authors' contribution
CL, JJ, and ZW designed research; CL, JJ, ZW, and Y T conducted research; CL, JJ, ZW, and Y T analyzed data; CL and ZW wrote the first draft of the manuscript; CL and YT had primary responsibility for final content. All authors read and approved the final manuscript.

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Data availability
All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate
In this study, all methods were performed in accordance with the relevant guidelines and regulations. Ethical approval and written informed consent were not necessary since our study was a meta-analysis.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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