BMC Neurology

RESEARCH

Open Access

# Effects of early supplemental parenteral nutrition on new-onset infection in adults with acute severe stroke: a single-center retrospective case–control study

Chen Ma[1†], Zhirong Fan[1†], Xuan Wang[1], Bian Li[2], Jingjing Zhao[1], Xiaogang Kang[1], Wen Jiang[1*] and Fang Yang[1*]

## Abstract

**Background** Early adequate feeding reduces mortality in patients with acute severe stroke. Supplemental parenteral nutrition (SPN) may address enteral nutrition (EN) deficiency and mitigate the risk of nosocomial infection. The benefit of the EN plus early SPN strategy over the full EN strategy is unknown in acute severe stroke patients.

**Methods** We retrospectively enrolled 20 patients with acute severe stroke in the SPN group who received EN plus early SPN (more than 50% of the energy target within 72 h after admission). Forty control patients in the EN group who received full EN were matched by age, sex and lesion site. The time to new-onset pneumonia or nosocomial infections was analyzed by Student's t test and the Breslow generalized Wilcoxon test.

**Results** The baseline characteristics did not differ significantly between the SPN group and the EN group, except for higher serum leukocyte counts, neutrophil counts, and neutrophil-to-lymphocyte ratios in the SPN group ($P<0.05$). Compared with that in the EN group, the time to new-onset pneumonia was significantly delayed in the SPN group (7.6 days vs. 5.2 days; mean difference, 2.5 days; 95% CI, 0.65 to 4.31; $P=0.009$), as was the time to new-onset nosocomial infections (7.1 days vs. 4.8 days; mean difference, 2.3 days; 95% CI, 0.46 to 4.07; $P=0.015$). Kaplan–Meier analysis revealed similar cumulative probabilities of new-onset pneumonia and new-onset nosocomial infections in the two groups ($P>0.05$). The rates of digestive intolerance events were similar between the two groups (40% in the SPN group vs. 52.5% in the EN group, $P=0.361$).

**Conclusions** In patients with acute severe stroke, the application of EN plus early SPN could delay the onset of pneumonia and nosocomial infections especially in the early phase.

**Keywords** Acute severe stroke, Supplemental parenteral nutrition, Enteral nutrition, New-onset pneumonia, New-onset nosocomial infections, Case–control study

†Chen Ma and Zhirong Fan these authors contributed equally to this work.

*Correspondence:
Wen Jiang
jiangwen@fmmu.edu.cn
Fang Yang
fyangx@fmmu.edu.cn
Full list of author information is available at the end of the article

© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

## Introduction

Severe stroke accounts for approximately 10% of all strokes and typically accompanies severe neurological disability and multiple system dysfunctions [1]. Stroke-associated pneumonia (SAP) is a major early complication of acute severe stroke, which may prolong hospitalization duration, increase medical costs, delay the duration of rehabilitation, and is closely associated with poor prognosis and mortality [2, 3]. The management of SAP has been proven to be highly important for the overall improvement of long-term stroke prognosis [4, 5].

Currently, there are no international guidelines or expert consensuses on the standardized management of nutrition after stroke. Early nutritional support with the enteral nutrition (EN) approach for critically ill patients with stroke is part of standard care for patients with a decreased level of consciousness or prolonged severe dysphagia [6, 7]. However, dysphagia caused by consciousness disorders or aspiration in patients receiving EN support is one of the major pathogeneses of SAP [8]. In addition, the EN approach may be interrupted for various reasons and often fail to achieve targeted energy delivery [9]. In recent years, parenteral nutrition (PN) has been widely used in the clinic because of its ability to reduce the incidence of adverse events [10]. Several studies have shown that early optimized SPN nutrition can serve as an effective strategy for addressing EN deficiency in intensive care units and mitigating the risk of nosocomial infection [11, 12], whereas other studies suggest opposite conclusions and suggest that early PN not be used in combination with EN to increase the complication rate [13, 14]. The benefit of the early nutrition strategy of EN plus SPN is still controversial, and its advantage over the full EN approach in acute severe stroke is unknown. In this study, we investigated the benefits of the EN plus SPN strategy over the full EN strategy on the occurrence of new-onset pneumonia and new-onset nosocomial infections in patients with severe stroke.

## Methods

### Study patients

We conducted a retrospective case–control study in patients with acute severe stroke. From November 1, 2021 to May 1, 2024, a total of 297 consecutive patients with acute severe stroke were admitted to Xijing Hospital. Patients with severe stroke met the inclusion criteria if they were 18 years or older, admitted in our department within 3 days after stroke onset, and received enteral nutrition or parenteral nutrition due to a water swallow test score $\geq 3$ or a consciousness disorder. Severe stroke was defined as patients with an initial Glasgow Coma Scale (GCS) score $\leq 12$ or with a National Institutes of Health Stroke Scale (NIHSS) score $\geq 11$ [15, 16].Patients were excluded if they were currently receiving total parenteral nutrition, had contraindications to enteral nutrition, had a history of gastrectomy or enterectomy, had severe systemic disease, had unstable vital signs, were documented to have pre-stroke dementia or disability, or used steroids or immunosuppressants. Unstable vital signs were defined as a systolic arterial pressure less than 90 mmHg or a mean arterial pressure less than 60 mmHg, a decrease of more than 30 mmHg from baseline, a drug/device used to maintain blood pressure above these targets, respiratory failure (oxygenation index $< 200$) or an abnormal respiratory rhythm.

EN was administered to patients in our department who were unable to receive oral nutrition, following standard protocols. Patients were permitted initial nutritional support with the EN plus early SPN approach if they had fever, elevated markers of inflammation or a high risk of aspiration. High aspiration risks included significant disturbances in consciousness, dysphagia, repeated vomiting, and reduced airway defense. For each patient in the SPN group, two matched patients who underwent the full EN approach were included in the EN group. Baseline characteristics, including age differences ($\leq 5$ years), sex and lesion site, were matched to improve the balance of the two datasets. A flow diagram of the included and excluded patients is provided in Fig. 1. The study was approved by the Ethics Committee of Xijing Hospital (KY20182024-F-1). Informed consent was obtained from the patients or their next of kin.

### Nutritional protocol

A weight-based Eq. (25 kcal/kg/day) was used to estimate the energy requirements. For patients with a body mass index (BMI) between 18 kg/m$^2$ and 24.8 kg/m$^2$, the daily caloric requirement (kcal) = actual weight (in kg) $\times$ 25 (kcal). For patients with a BMI $< 18$ kg/m$^2$ or BMI $> 24.8$ kg/m$^2$, the daily caloric requirement (kcal) = [height [in cm] $-100$(female)/105(male)] $\times$ 25 (kcal). The protein supplement for all participants from Day 1 was 1.2–1.5 g/kg/day. The caloric target on Day 1 was one-third of the estimated need, the target on Day 2 was one-half of the estimated need, and the targets from Day 3 to Day 7 were 100% of the estimated need, with an acceptable range of 70–100%. Early SPN was initiated within 72 h after admission and accounted for more than 50% of the daily energy target in the SPN group. A small amount of PN was allowed in the EN group. Parenteral energy was delivered in a mixed way via a ready-to-mix 3-chamber bag (14% protein, 46% lipids, and 40% carbohydrates), or a physician preparation containing glucose, lipids, amino acids, electrolytes, trace elements, minerals,

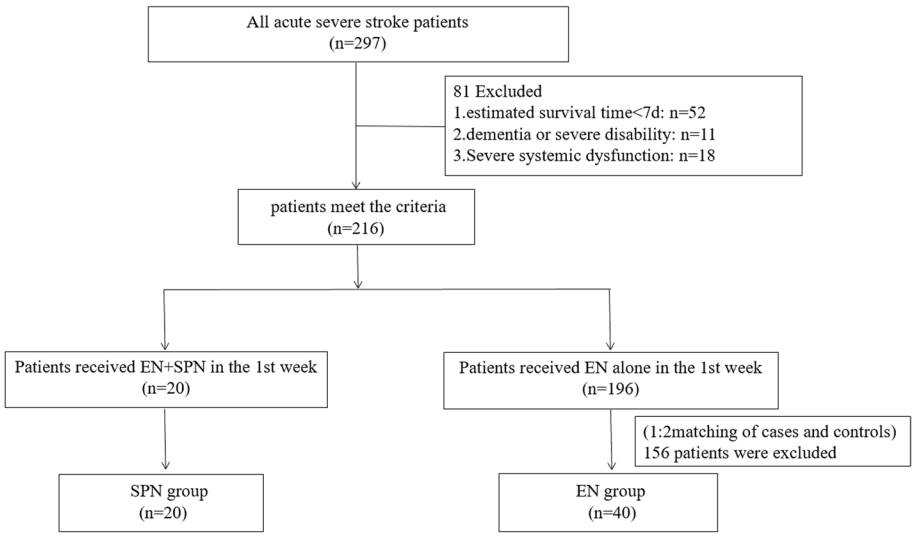


**Fig. 1** Flow diagram of the included and excluded patients

and vitamins was added as clinically appropriate. EN was administered continuously according to routine protocols through the placement of nasogastric or nasointestinal feeding tubes, and the use of prokinetic agents if necessary (gastric residual volume ≥ 100 mL). The EN formulation was selected according to the main patient's problem and contained 0.81–1.26 kcal/mL of energy. To meet the energy requirements, unnecessary reduction of the EN was forbidden in the EN group. Patients in the SPN group received hypocaloric enteral nutrition support (30% of estimated caloric requirements provided by 500 ml daily).

## Data collection

Demographic features; medical history; clinical scores from the National Institutes of Health Stroke Scale (NIHSS), Glasgow Coma Scale (GCS) and Nutrition Risk Screening 2002 (NRS-2002); laboratory test and vital sign data; and durations of intensive care unit (ICU) stay and mechanical ventilation were recorded. The daily nutritional data (total calories and protein), gastric residual volumes, and blood glucose levels were checked four times (at 0800 h, 1200 h, 1600 h, and 2000 h) daily during the first 7 days. Clinical scores were assessed at ICU admission and discharge. During the entire period of hospitalization, adverse events, vital signs, and concomitant treatment data were collected. The modified Rankin scale (mRS) score was assessed by an investigator who was unaware of group allocation by telephone at 90 days [17]. The reference ranges for the laboratories are shown in Table S1.

## Study outcomes

The primary outcomes were the time to new-onset pneumonia and the time to new-onset nosocomial infections. The diagnosis of new-onset pneumonia is made by a professional respiratory physician based on the patient's symptoms, such as a temperature higher than 38 °C or lower than 36 °C, cough, dyspnea, purulent tracheobronchial secretions, leukocytosis > 12,000/$mm^3$ or leukopenia < 4000/$mm^3$, the presence of a new or progressive radiologic pulmonary infiltrate on the chest X-ray or CT, and positive culture from respiratory secretions [18, 19]. Nosocomial infections include infections of the urogenital tract, abdomen, blood, skin, bone, soft tissue, ear, nose, throat, upper respiratory tract, and intrathoracic infections [20]. For patients with pre-admission infections, new-onset pneumonia or nosocomial infection was diagnosed only when there was no other recognized cause for fever, altered mental status, reaggravated inflammatory markers, or chest radiograph progress. The secondary outcomes were the proportion of new-onset pneumonia and new-onset nosocomial infections within 7 days of hospitalization, the rates of digestive intolerance events; the GCS score; the NIHSS score; mRS at ICU discharge; the duration of mechanical ventilation, the length of ICU stay, mortality at ICU discharge; mortality on Day 90; and poor outcomes on Day 90. A poor outcome on Day 90 was defined as an mRS score of 3 or greater. The safety outcomes were the incidence of digestive intolerance, cerebral herniation, heart failure, respiratory failure, renal failure, sepsis, or septic shock. Digestive intolerance reflected by gastric retention was defined as more than

200 mL of residual gastric volume for two consecutive checks.

### Statistical analysis

We used Stata 12.0 software for all the statistical analyses. Differences in demographic and clinical features at baseline were evaluated between groups with the Wilcoxon rank-sum test for continuous variables and with the chi-square test for categorical variables. To improve the balance of baseline characteristics, matching of baseline features, including age, sex, and lesion site, was used to create a 1–2 matched dataset. Student's t tests were performed for between-group comparisons in time to new-onset pneumonia or new-onset nosocomial infections. We constructed Kaplan–Meier curves and used the Breslow generalized Wilcoxon test to estimate the cumulative probability of new-onset pneumonia or new-onset nosocomial infections. A $P$ value < 0.05 was considered statistically significant.

## Results

### Study population

We identified 20 pairs of patients in the SPN group and the EN group. The demographic characteristics are summarized in Table 1. Baseline characteristics were similar between the SPN group and the EN group ($P > 0.05$), including age, sex, weight, body mass index (BMI), previous disease, oxygenation index, stroke severity at baseline as reflected by the NIHSS and GCS score, nutritional status as reflected by the serum albumin, prealbumin level and NRS-2002 score. Compared with patients in the EN group, patients in the SPN group had higher serum leukocyte (11.4 vs. 9.5, $P = 0.04$) and neutrophil (10.2 vs. 7.3, $P = 0.008$) counts and neutrophil-to-lymphocyte ratios (15.97 vs. 7.12, $P = 0.001$).

### Nutritional support during hospitalization

The median caloric target was 1587 kcal/day in the SPN group and 1500 kcal/day in the EN group. The average caloric intake was similar between the SPN group and the EN group at 7 days after admission ($P > 0.05$) and reached the target value in both groups (Fig. 2). The median protein targets were similar in both groups (94.5 g /day in the SPN group vs. 93 g /day in the EN group) (Table S2). A total of 1022 and 506 blood glucose data points were collected form the EN group and the SPN group, respectively. Blood glucose concentrations did not significantly differ between the groups within 7 days ($P = 0.215$) (Fig. S1).

### New-onset infection and clinical outcomes

Compared with that of patients in the EN group, the time to new-onset pneumonia was significantly delayed in the SPN group (7.6 days in the SPN group vs. 5.2 days in the EN group; mean difference, 2.5 days; 95% CI, 0.65 to 4.31; $P = 0.009$). The proportion of new-onset pneumonia within 7 days was lower in the SPN group than in the EN group (35% vs. 50%, $P = 0.271$), but our study lacked the power to show statistically significant differences. The time to new-onset nosocomial infections was significantly delayed in the SPN group (7.1 days in the SPN group vs. 4.8 days in the EN group; mean difference, 2.3 days; 95% CI, 0.46 to 4.07; $P = 0.015$). There were no differences in the number of patients with urogenital infections or other new-onset nosocomial infections within 7 days of hospitalization ($P > 0.05$) (Table 2). Kaplan–Meier analysis revealed similar cumulative probabilities of new-onset pneumonia (Fig. 3A) and new-onset nosocomial infections (Fig. 3B). There were no significant differences in the median time to new-onset pneumonia (8.0 days, 95% CI [6.4 to 9.6] in the SPN group; 7.0 days, 95% CI [3.2 to 10.8] in the EN group; $P = 0.173$ for the Breslow generalized Wilcoxon test) or in the time to new-onset nosocomial infections (8.0 days, 95% CI [6.7 to 9.3] in the SPN group; 7.0 days, 95% CI [2.9 to 11.1] in the EN group; $P = 0.282$ for the Breslow generalized Wilcoxon test). There were no significant differences in disease severity at ICU discharge, as reflected by the GCS, NIHSS and mRS scores ($P > 0.05$), or in mechanical ventilation duration during hospitalization, length of stay in the ICU, ICU mortality, 90-day mortality, or poor outcome on Day 90 (Table 2).

### Safety outcomes

The rate of digestive intolerance events was similar between the SPN group and the EN group (40% vs. 52.5%, $P = 0.361$). The incidences of cerebral herniation, heart failure, respiratory failure, renal failure, sepsis, and septic shock were similar between the two groups. The results are shown in Table S3.

## Discussion

We found that nutritional support with the EN plus early SPN approach in patients with acute severe stroke could significantly delay the time to new-onset pneumonia or new-onset nosocomial infections compared to those with the full EN approach. With the extension of hospital stay, the cumulative probability of infection became similar between the two groups. Our results highlight the potential value of EN plus an early SPN nutritional strategy for patients with acute severe stroke to mitigate infection in the early phase after admission.

The FOOD study revealed that early feeding reduced the mortality of stroke patients with dysphagia [21]. Moreover, the results from the OPENS trial suggest that hypocaloric feeding during the acute phase of severe

**Table 1** Baseline demographic and clinical characteristics

| | SPN group, $n=20$ | EN group, $n=40$ | *P*-value |
|---|---|---|---|
| Demographics | | | |
| Age, y | 69.0 ± 14.3 | 69.4 ± 12,6 | 0.912 |
| male, n (%) | 10(50) | 20(50) | > 0.99 |
| Weight, kg | 66.7 ± 12.0 | 61.9 ± 11.3 | 0.134 |
| Body-mass index, kg/m$^2$ | 24.2 ± 3.6 | 23.1 ± 3.1 | 0.248 |
| Vital signs | | | |
| Temperature, ℃ | 37.2(36.8, 37.7) | 37.1(36.8, 37.4) | 0.615 |
| Oxygenation index | 253.7 ± 96.5 | 272.8 ± 119.0 | 0.537 |
| Time from stroke onset to admission, h | 24(5, 24) | 10.5(6, 24) | 0.565 |
| Illness severity on admission | | | |
| NIHSS | 20(17, 33.7) | 17(14, 25.5) | 0.116 |
| GCS | 8(5.25, 10) | 9(7, 11) | 0.124 |
| NRS 2002 | 3(3, 4) | 3 (3, 3) | 0.746 |
| Complications | | | |
| Hypertension, n (%) | 13(65) | 28(70) | 0.695 |
| Previous stroke, n (%) | 6(30) | 11(27.5) | 0.839 |
| Diabetes, n (%) | 5(25) | 13(32.5) | 0.55 |
| Coronary artery disease, n (%) | 8(40) | 12(30) | 0.439 |
| Renal disease, n (%) | 1(5) | 3(7.5) | > 0.99 |
| Pneumonia, n (%) | 6(30) | 6(15) | 0.304 |
| Thrombolytic therapy, n (%) | 2(10) | 6(15) | 0.893 |
| Endovascular therapy, n (%) | 11(55) | 22(55) | > 0.99 |
| Laboratory tests | | | |
| Leukocyte, × 10$^9$ | 11.4(8.4, 15.0) | 9.5(7.6, 10.8) | 0.04 |
| Neutrophil, × 10$^9$ | 10.2(6.9, 13.8) | 7.3(5.9, 8.9) | 0.008 |
| Lymphocyte, × 10$^9$ | 0.63(0.48, 0.93) | 0.95(0.82, 1.57) | 0.001 |
| Neutrophil/lymphocyte | 15.97(9.09, 21.89) | 7.12(4.78, 10.21) | 0.001 |
| Procalcitonin, ng/ml | 0.14(0.03, 0.40) | 0.06(0.04, 0.11) | 0.075 |
| Interleukin-6, pg/ml | 35.8(14.3, 77.9) | 19.1(11.3, 57.5) | 0.17 |
| Albumin, g/L | 36.2(34.7, 42.6) | 38.2(35.6, 40.8) | 0.541 |
| Prealbumin, g/L | 0.13(0.10,0.21) | 0.18(0.13, 0.21) | 0.237 |
| Triglyceride, mmol/L | 0.69(0.53, 1.32) | 1.01(0.75, 1.43) | 0.115 |
| Cholesterol, mmol/L | 4.07 ± 1.04 | 3.99 ± 1.17 | 0.824 |
| $HbA_{1C}$, % | 6.05(5.72, 6.52) | 5.9(5.45, 10.2) | 0.522 |
| Creatinine, μmol/L | 64.5(50.7, 84.5) | 66.0(56.2, 98.7) | 0.342 |

*NIHSS* National Institutes of Health Stroke Scale, *GCS* Glasgow Coma Scale, *NRS-2002* Nutrition Risk Screening 2002, *IQR* interquartile range. Continuous variables were presented as mean ± SD or median (IQR). Categorical variables were presented as number (%)

stroke might be associated with increased mortality [22]. However, several patients may experience feeding interruption and caloric deficits, resulting in complications that affect the prognosis [23, 24]. Pneumonia, a frequent complication associated with aspiration in stroke, is closely related to disease severity and prognosis [25]. Therefore, finding optimal feeding strategies and avoiding an inadequate energy supply are crucial clinical issues.

The latest study revealed that individually optimized energy supplementation with SPN starting 4 days after ICU admission could reduce nosocomial infections [11]. In this study, some patients developed fever, accompanied by increased inflammatory mediator levels within 48 h after admission. Considering the combination of disturbance of consciousness and high aspiration risk, we chose the modified SPN nutritional approach. The time of parenteral nutrition initiation in the SPN group was 2.4 ± 0.6 days after admission. Like in the above trials, PN was activated early in our study. However, the population in our study was adults with severe stroke, and PN

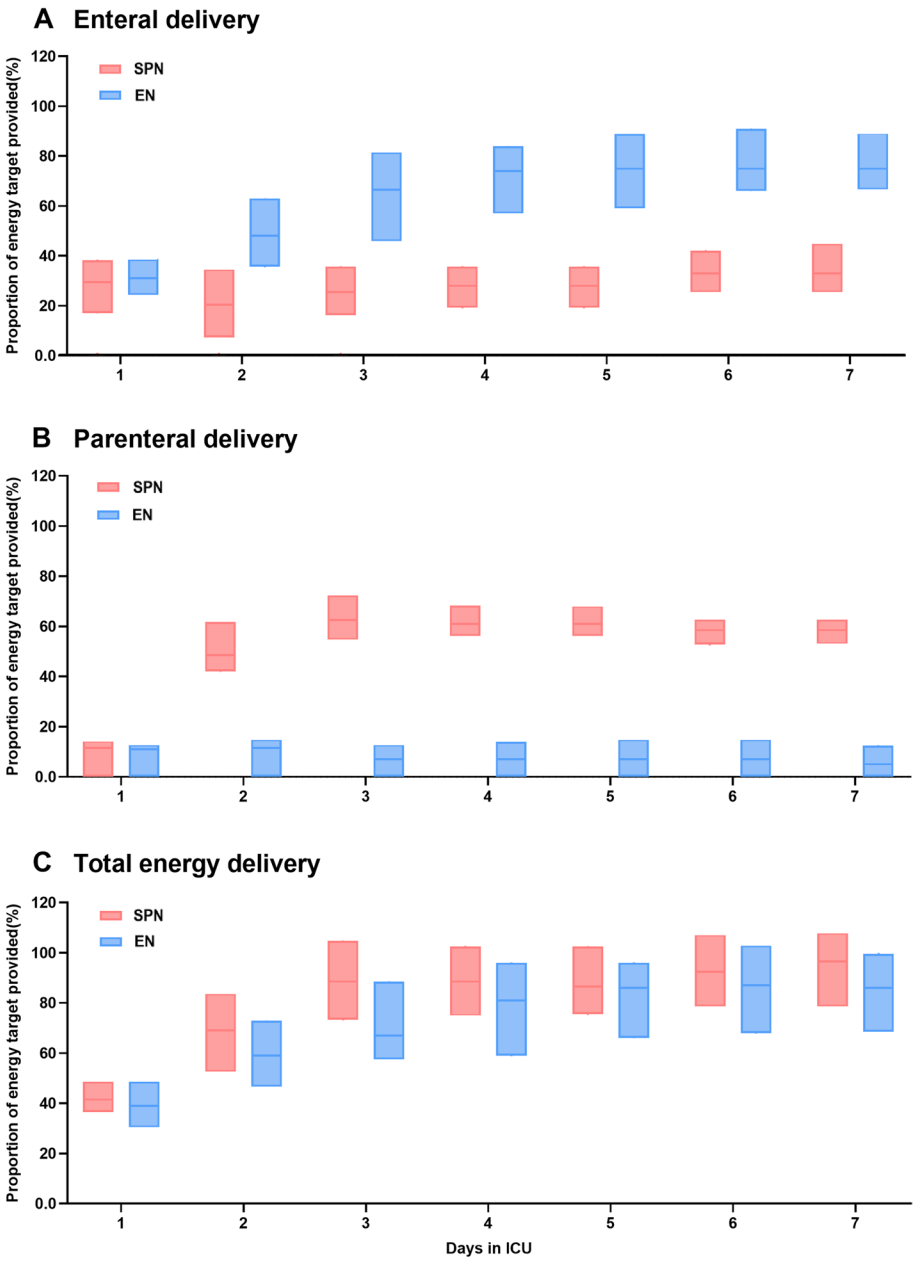


**Fig. 2** Energy delivery. Energy is expressed in percentage (%) of energy target according to method of delivery: enteral route (**A**), parenteral route (**B**), or a combination of both routes (**C**) in patients. Horizontal lines within the boxes show the median, and the boxes show IQR. EN = enteral nutrition. SPN = supplemental parenteral nutrition. ICU = intensive-care unit. NIHSS, National Institutes of Health Stroke Scale; GCS, Glasgow Coma Scale; NRS-2002, Nutrition Risk Screening 2002; IQR, interquartile range

feeding was added obviously to reduce the risk of pneumonia in the SPN group in conjunction with the use of EN. There were no significant differences in nutrient supply or blood glucose between the two groups, indicating that SPN is effective and feasible.

Poststroke inflammation plays an important role in various stages of stroke. Neutrophil-to-Lymphocyte Ratio (NLR) as a newfound biomarker in systematic inflammation was proved to possess predictive capabilities in SAP recently [26]. The results revealed that the serum leukocyte count, neutrophil count and NLR in the SPN group were significantly increased, suggesting that these patients may be at increased risk of pneumonia according to clinical assessment by clinicians. Consistent with previous studies, our results showed that the incidence of new-onset pneumonia was similar between

**Table 2** Distribution of new-onset infections within 7 days of hospitalization and clinical outcomes in different nutrition strategies group

| | SPN group, $n=20$ | EN group, $n=40$ | *P*-value |
|---|---|---|---|
| New-onset pneumonia within 7 days, n (%) | 7(35) | 20(50) | 0.271 |
| Time of new-onset pneumonia, days | 7.6 ± 2.1 | 5.2 ± 3.0 | 0.009 |
| Urogenital infection within 7 days, n (%) | 2(10) | 2(5) | 0.855 |
| Other infection within 7 days, n (%) * | 1 | 0 | 0.721 |
| New-onset nosocomial infections within 7 days, n (%) | 9(45) | 21(52.5) | 0.584 |
| Time of new-onset nosocomial infections, days | 7.1 ± 2.4 | 4.8 ± 2.9 | 0.015 |
| Invasive mechanical ventilation, n (%) | 7(35) | 7(17.5) | 0.235 |
| Hours on mechanical ventilation, days | 0(0, 3.5) | 0(0, 0) | 0.208 |
| Glasgow Coma Scale at discharge | 11(9.25, 14) | 12(10, 15) | 0.668 |
| NIHSS at discharge | 15(11.5, 19.2) | 14.5(11, 22) | 0.956 |
| Modified Rankin Scale at discharge | 5(4, 5) | 4(4, 5) | 0.251 |
| Days in ICU, days | 14.5(10, 19.2) | 11(8, 14) | 0.081 |
| mortality in ICU, n (%) | 0 | 2(5) | 0.799 |
| Death at day 90, n (%) | 1(5) | 5(12.5) | 0.648 |
| Poor outcome at day 90, n (%) | 19(95) | 38(95) | > 0.99 |

*SPN* supplemental parenteral nutrition, *EN* enteral nutrition, *NIHSS* National Institutes of Health Stroke Scale

* Other infection included infections of abdominal, bloodstream, skin, bone, soft tissue, ear, nose, throat, upper respiratory, and non-pulmonary intrathoracic. Continuous variables were presented as mean ± SD or median (IQR). Categorical variables were presented as number (%)

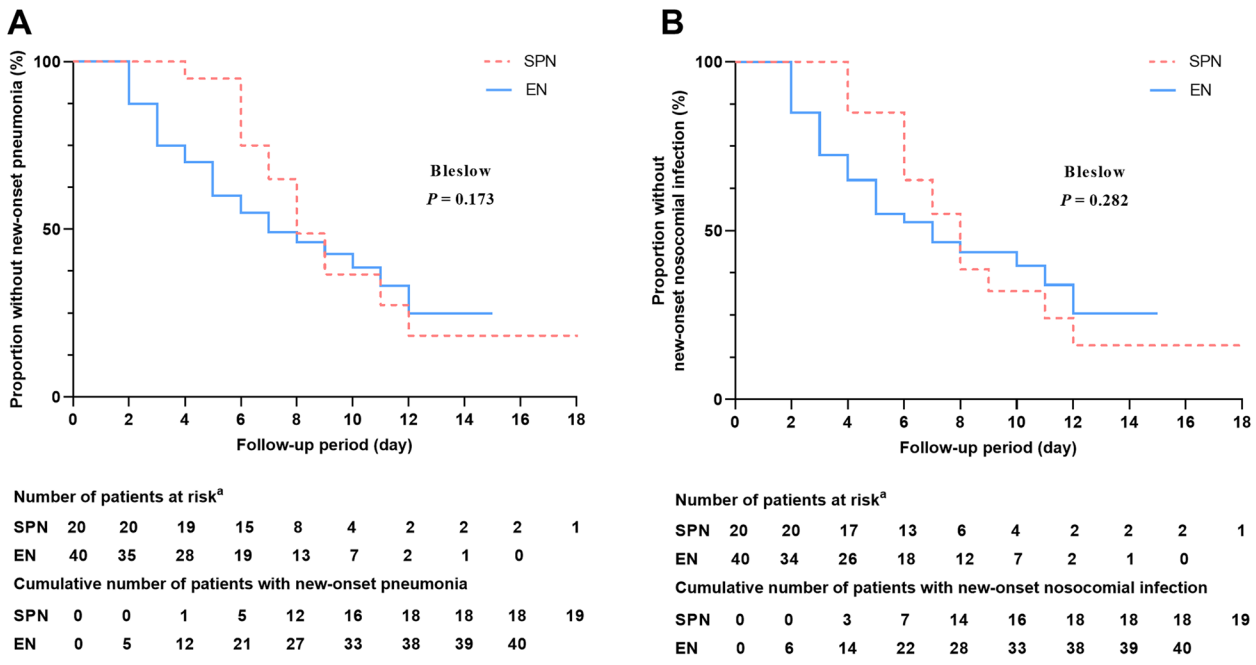


**Fig. 3** Kaplan–Meier analysis of new-onset pneumonia (**A**) and new-onset nosocomial infections (**B**). SPN, supplemental parenteral nutrition; EN, enteral nutrition; NIHSS, National Institutes of Health Stroke Scale. Other infection included infections of abdominal, bloodstream, skin, bone, soft tissue, ear, nose, throat, upper respiratory, and non-pulmonary intrathoracic

the two groups within 7 days of hospitalization. Our findings are consistent with those of a randomized trial that included critically ill ICU patients [27], but are inconsistent with those of another study [11]. The following reasons could account for this inconsistency. The population in our study included severe stroke patients with a high incidence of pneumonia and respiratory failure, and these patients may benefit more from optimized

feeding methods. Moreover, the mean age of the patients was nearly 70 years, which was older than that reported in previous studies (where the mean age was 60 years), and the patients all had high clinical scores at admission. Advanced age and stroke severity are risk factors for SAP. In such patients, the overall incidence of pneumonia was increased, and the heterogeneity of critically ill patients was high; consequently, it was difficult to determine a significant difference.

Compared with the full EN strategy, the EN plus early SPN strategy had a delayed onset of infection but had a similar cumulative incidence during hospitalization. This phenomenon has rarely been discussed in previous articles and might be explained by the fact that the nutritional supply pathway may not be a determining factor for pneumonia and infections. There were no differences in the duration of mechanical ventilation, average length of stay in the ICU, or ICU mortality between the two groups, which is consistent with the finding of a randomized controlled trial [11] and a review [28]. It has been suggested that SPNs are safe for use in these patients, although no efficacy for long-term prognosis has been reported.

Several potential limitations need to be taken into account. First, our study was designed as a retrospective study with a limited sample size and relatively low statistical power. Our strict inclusion criteria, as well as case–control 1:2 matching, could represent broader populations of patients with severe stroke. Second, the EN or PN regimens given to the patients were not the same specific formulations. Although it could confound the effects on inflammatory mediators, laboratory results, gastrointestinal tolerance, and clinical outcomes, this approach is pragmatic in real-world medical practice. Third, prior to admission, patients might have received short-term parenteral or enteral nutritional support; however, the precise regimen and caloric intake are challenging to calculate accurately. Following admission to our department, the nutritional protocol detailed in the Methods section was rigorously adhered to. Finally, the clinical diagnosis of new-onset pneumonia and nosocomial infection is a comprehensive judgment made by physicians based on clinical manifestations and auxiliary examinations, which largely depends on the accurate and complete medical records. The CRP values were missing for most of our patients. More inflammatory markers should be collected and analyzed to reflect preadmission infections inexactly. Due to the retrospective nature of the study, biases such as the higher rate of antibiotic usage in the SPN group and the difficulty of distinguishing between pre-infection and acquired infection, could not be entirely avoided. To minimize these biases, we introduced the definition of new-onset infection for patients with pre-admission infection. Our results deserve close clinical attention and require further validated through prospective, randomized controlled studies. Additionally, future studies should exclude patients with preadmission infections.

## Conclusion

The nutritional strategy of EN plus early SPN might be an alternative to the full EN strategy for patients with acute severe stroke, especially those at high risk of infection.

### Abbreviations

| | |
|---|---|
| NICU | Neurology intensive care unit |
| EN | Enteral nutrition |
| PN | Parenteral nutrition |
| SPN | Supplemental parenteral nutrition |
| NIHSS | National Institutes of Health Stroke Scale |
| GCS | Glasgow Coma Scale |
| mRS | Modified Rankin Scale score |
| NRS-2002 | Nutrition Risk Screening 2002 |
| SAP | Stroke-associated pneumonia |
| BMI | Body mass index |
| IQR | Interquartile range |
| NLR | Neutrophil to Lymphocyte Ratio |
| NEU | Neutrophil |
| LYM | Lymphocyte |
| PCT | Procalcitonin |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12883-025-04050-6.

Supplementary Material 1.

### Acknowledgements

Not applicable.

### Authors' contributions

F.Y. and W.J. designed the study. C.M., B.L, and X.K. collected the data. C.M., Z.F., and X.W. analyzed the data. J.Z. and X.K. revised the statistical analyses. C.M. and Z.F. wrote the manuscript. F.Y. and W.J. revised the manuscript. All authors have read and agreed to the published version of the manuscript.

### Funding

This study was supported by the Funding Key Research and Development Project of Shaanxi Province (No.2020SF-306) and the Xijing Hospital Clinical Application Research Program (No. JSYXM03).

### Data availability

No datasets were generated or analysed during the current study.

## Declarations

### Ethics approval and consent to participate

The procedures of this study were approved by the ethics committee of Xijing Hospital (KY20182024-F-1) and adhered to the Helsinki Declaration. Informed consent was obtained from the patients or their next of kin.

### Consent for publication

Not applicable.

**Competing interests**
The authors declare no competing interests.

**Author details**
[1]Department of Neurology, Xijing Hospital, Air Force Medical University, Xi'an, Shaanxi Province, China. [2]General Medicine Department, Air Force Medical University, Xi'an, Shaanxi Province, China.

Received: 22 September 2024 Accepted: 21 January 2025
Published online: 31 January 2025

**References**

1. Luengo-Fernandez R, Paul NL, Gray AM, Pendlebury ST, Bull LM, Welch SJ, Cuthbertson FC, Rothwell PM. Stroke. 2013;44(10):2854–61.
2. Banda KJ, Chu H, Kang XL, Liu D, Pien LC, Jen HJ, Hsiao SS, Chou KR. Prevalence of dysphagia and risk of pneumonia and mortality in acute stroke patients: a meta-analysis. BMC GERIATR. 2022;22(1):420.
3. Grossmann I, Rodriguez K, Soni M, Joshi PK, Patel SC, Shreya D, Zamora DI, Patel GS, Sange I. Stroke and Pneumonia: Mechanisms, Risk Factors, Management, and Prevention. CUREUS J MED SCIENCE. 2021;13(11): e19912.
4. Koennecke HC, Belz W, Berfelde D, Endres M, Fitzek S, Hamilton F, Kreitsch P, Mackert BM, Nabavi DG, Nolte CH, et al. Factors influencing in-hospital mortality and morbidity in patients treated on a stroke unit. Neurology. 2011;77(10):965–72.
5. Westendorp WF, Nederkoorn PJ, Vermeij JD, Dijkgraaf MG, van de Beek D. Post-stroke infection: a systematic review and meta-analysis. BMC NEUROL. 2011;11:110.
6. Burgos R, Breton I, Cereda E, Desport JC, Dziewas R, Genton L, Gomes F, Jesus P, Leischker A, Muscaritoli M, et al. ESPEN guideline clinical nutrition in neurology. CLIN NUTR. 2018;37(1):354–96.
7. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, Biller J, Brown M, Demaerschalk BM, Hoh B, et al. Guidelines for the Early Management of Patients With Acute Ischemic Stroke: 2019 Update to the 2018 Guidelines for the Early Management of Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. Stroke. 2019;50(12):e344–418.
8. Hannawi Y, Hannawi B, Rao CP, Suarez JI, Bershad EM. Stroke-associated pneumonia: major advances and obstacles. CEREBROVASC DIS. 2013;35(5):430–43.
9. Uozumi M, Sanui M, Komuro T, Iizuka Y, Kamio T, Koyama H, Mouri H, Masuyama T, Ono K, Lefor AK. Interruption of enteral nutrition in the intensive care unit: a single-center survey. J INTENSIVE CARE. 2017;5:52.
10. Doig GS, Simpson F, Sweetman EA, Finfer SR, Cooper DJ, Heighes PT, Davies AR, O'Leary M, Solano T, Peake S. Early parenteral nutrition in critically ill patients with short-term relative contraindications to early enteral nutrition: a randomized controlled trial. JAMA-J AM MED ASSOC. 2013;309(20):2130–8.
11. Heidegger CP, Berger MM, Graf S, Zingg W, Darmon P, Costanza MC, Thibault R, Pichard C. Optimisation of energy provision with supplemental parenteral nutrition in critically ill patients: a randomised controlled clinical trial. Lancet. 2013;381(9864):385–93.
12. Gao X, Liu Y, Zhang L, Zhou D, Tian F, Gao T, Tian H, Hu H, Gong F, Guo D, et al. Effect of Early vs Late Supplemental Parenteral Nutrition in Patients Undergoing Abdominal Surgery: A Randomized Clinical Trial. JAMA SURG. 2022;157(5):384–93.
13. Casaer MP, Mesotten D, Hermans G, Wouters PJ, Schetz M, Meyfroidt G, Van Cromphaut S, Ingels C, Meersseman P, Muller J, et al. Early versus late parenteral nutrition in critically ill adults. NEW ENGL J MED. 2011;365(6):506–17.
14. Sena MJ, Utter GH, Cuschieri J, Maier RV, Tompkins RG, Harbrecht BG, Moore EE, O'Keefe GE. Early supplemental parenteral nutrition is associated with increased infectious complications in critically ill trauma patients. J AM COLL SURGEONS. 2008;207(4):459–67.
15. Lyden P, Brott T, Tilley B, Welch KM, Mascha EJ, Levine S, Haley EC, Grotta J, Marler J. Improved reliability of the NIH Stroke Scale using video training. Ninds TPA Stroke Study Group STROKE. 1994;25(11):2220–6.
16. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale Lancet. 1974;2(7872):81–4.
17. van Swieten JC, Koudstaal PJ, Visser MC, Schouten HJ, van Gijn J. Interobserver agreement for the assessment of handicap in stroke patients. Stroke. 1988;19(5):604–7.
18. Badve MS, Zhou Z, van de Beek D, Anderson CS, Hackett ML. Frequency of post-stroke pneumonia: Systematic review and meta-analysis of observational studies. Int J Stroke. 2019;14(2):125–36.
19. Kalil AC, Metersky ML, Klompas M, Muscedere J, Sweeney DA, Palmer LB, Napolitano LM, O'Grady NP, Bartlett JG, Carratala J, et al. Management of Adults With Hospital-acquired and Ventilator-associated Pneumonia: 2016 Clinical Practice Guidelines by the Infectious Diseases Society of America and the American Thoracic Society. Clin Infect Dis. 2016;63(5):e61–111.
20. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control. 2008;36(5):309–32.
21. Dennis MS, Lewis SC, Warlow C. Effect of timing and method of enteral tube feeding for dysphagic stroke patients (FOOD): a multicentre randomised controlled trial. Lancet. 2005;365(9461):764–72.
22. Zhao J, Yuan F, Song C, Yin R, Chang M, Zhang W, Zhang B, Yu L, Jia Y, Ma Y, et al. Safety and efficacy of three enteral feeding strategies in patients with severe stroke in China (OPENS): a multicentre, prospective, randomised, open-label, blinded-endpoint trial. LANCET NEUROL. 2022;21(4):319–28.
23. Blumenstein I, Shastri YM, Stein J. Gastroenteric tube feeding: techniques, problems and solutions. WORLD J GASTROENTERO. 2014;20(26):8505–24.
24. Heyland DK, Dhaliwal R, Wang M, Day AG. The prevalence of iatrogenic underfeeding in the nutritionally "at-risk" critically ill patient: Results of an international, multicenter, prospective study. CLIN NUTR. 2015;34(4):659–66.
25. Finlayson O, Kapral M, Hall R, Asllani E, Selchen D, Saposnik G. Risk factors, inpatient care, and outcomes of pneumonia after ischemic stroke. Neurology. 2011;77(14):1338–45.
26. Khanzadeh S, Lucke-Wold B, Eshghyar F, Rezaei K, Clark A. The Neutrophil to Lymphocyte Ratio in Poststroke Infection: A Systematic Review and Meta-Analysis. DIS MARKERS. 2022;2022:1983455.
27. Fan M, Wang Q, Fang W, Jiang Y, Li L, Sun P, Wang Z. Early Enteral Combined with Parenteral Nutrition Treatment for Severe Traumatic Brain Injury: Effects on Immune Function, Nutritional Status and Outcomes. Chin Med Sci J. 2016;31(4):213–20.
28. Sharma SK, Rani R, Thakur K. Effect of Early Versus Delayed Parenteral Nutrition on the Health Outcomes of Critically Ill Adults: A Systematic Review. J Crit Care Med. 2021;7(3):160–9.

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.