

Effects of Closed Autologous Gastric Juice Reinfusion on Nutritional Tolerance and Immune Function in Patients with Sepsis and Gastrointestinal Dysfunction: A Single-Center, Retrospective Cohort Study

Huirong Shi

The People's Hospital of Guangxi Zhuang Autonomous Region

xiao gang wang

The People's Hospital of Guangxi Zhuang Autonomous Region

bin Xiong

The People's Hospital of Guangxi Zhuang Autonomous Region

lin han

The People's Hospital of Guangxi Zhuang Autonomous Region

fang liu

The People's Hospital of Guangxi Zhuang Autonomous Region

li lan

The People's Hospital of Guangxi Zhuang Autonomous Region

Jinyan Tang

The People's Hospital of Guangxi Zhuang Autonomous Region

Shulin xiang

The People's Hospital of Guangxi Zhuang Autonomous Region

jing pang

pppang.jing@163.com

The People's Hospital of Guangxi Zhuang Autonomous Region

Research Article

Keywords: Gastric juice reinfusion, Sepsis, Gastrointestinal dysfunction, Acute gastrointestinal function injury, Nutritional tolerance, Immune function

Posted Date: September 21st, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10641734/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.
[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

Gastrointestinal dysfunction is a common and prognostically unfavorable complication of sepsis. Enteral nutrition (EN) is essential for maintaining intestinal barrier integrity but is often limited by poor feeding tolerance. Gastric juice reinfusion may restore electrolyte and enzymatic balance, yet conventional open systems pose infection risks. The closed autologous system could reduce such hazards; however, its therapeutic value in septic patients with gastrointestinal impairment remains unclear. This study therefore compared closed autologous gastric juice reinfusion combined with EN versus EN alone in this population.

Methods

This single-center retrospective cohort study included 95 ICU patients with sepsis-related gastrointestinal dysfunction: 44 received closed autologous gastric juice reinfusion plus EN (intervention) and 51 received EN alone (control). Clinical and laboratory parameters were recorded at baseline and on days 1, 3, and 7. Multivariable regression and linear mixed-effects models were used, adjusting for age, sex, surgical history, hypertension, diabetes, and coronary heart disease. Primary outcomes were nutritional tolerance, disease severity (SOFA and APACHE II scores), immune indices, and 28-day all-cause mortality.

Results

Compared with the control group, the reinfusion group exhibited a marked reduction in both SOFA (SOFA; $\beta = -3.26$, 95%CI -5.00 to -1.52 , $P < 0.001$) and APACHE II scores at day 7, indicative of attenuated disease severity. Concurrently, the intervention group demonstrated significantly better enteral feeding tolerance and a notable elevation in lymphocyte counts, suggesting an immunomodulatory benefit. Most importantly, closed autologous reinfusion was independently associated with a substantially lower 28-day mortality rate (OR = 0.07, 95%CI 0.02–0.29, $P < 0.001$). Although serum sodium levels decreased marginally in the reinfusion group, they remained within clinically normal ranges, and no intergroup differences were observed regarding pH, serum potassium, glucose, or hemoglobin concentrations.

Conclusions

In septic patients with gastrointestinal dysfunction, closed autologous gastric juice reinfusion plus standard enteral nutrition significantly improved nutritional tolerance, reduced organ injury, enhanced lymphocyte-mediated immunity, and increased short-term survival. This closed system appears safe and

feasible as an adjunctive strategy, though prospective randomized trials are needed to confirm these retrospective findings and assess broader applicability.

Trial registration:

not applicable.

Introduction

The gastrointestinal tract ranks among the most vulnerable target organs in sepsis, where disruption of intestinal epithelial integrity, heightened mucosal permeability, and subsequent bacterial translocation collectively instigate a self-perpetuating cycle of gut-derived systemic infection [1, 2]. This pathophysiological cascade not only constitutes a frequent complication in critically ill patients but also directly correlates with adverse clinical outcomes and increased mortality in the intensive care unit (ICU) [3, 4]. Given that sepsis and shock exacerbate acute gastrointestinal injury—culminating in epithelial necrosis, barrier failure, and polymicrobial translocation that may precipitate multiple organ dysfunction—restoration of gut barrier function has been established as a pivotal therapeutic priority in septic management [5].

Early enteral nutrition (EN) serves as a fundamental intervention to modulate excessive systemic inflammation and preserve intestinal mucosal architecture, thereby upholding the physical and immunological components of the gut barrier [6–8]. Nevertheless, the clinical implementation of EN in septic patients is frequently constrained by feeding intolerance, a multifaceted syndrome encompassing vomiting, elevated gastric residual volume, diarrhoea, abdominal distension, gastrointestinal haemorrhage, and enterocutaneous fistulas [4, 5]. Feeding intolerance remains the predominant impediment to adequate nutrient delivery. Notably, data from large-scale multicenter cohorts reveal that approximately 24% of ICU patients experience feeding intolerance within the first week of admission, and persistent intolerance has been independently identified as a mortality risk factor in this population [9].

In septic patients, EN intolerance typically manifests as acute gastrointestinal dysmotility with pronounced gastric retention. Routine gastrointestinal decompression is often employed to mitigate abdominal distension, regurgitation, and pulmonary aspiration; however, this manoeuvre inevitably incurs substantial loss of gastric fluid, predisposing patients to profound water, electrolyte, and acid-base derangements. Such iatrogenic losses not only aggravate pre-existing feeding intolerance and exacerbate protein-energy malnutrition but also heighten the susceptibility to infectious complications, collectively driving a trajectory toward poor prognosis [10]. Given that adults secrete 1,500–2,000 mL of gastric juice daily—a complex biofluid containing water, electrolytes, proteins, lipids, peptide hormones, gastric acid, mucin, pepsinogen, and intrinsic factor—its composition cannot be fully replicated by any available enteral formula, underscoring the physiological imperative for its conservation and reutilization.

Pioneering work by Wolfer in 1935 first demonstrated the feasibility of gastric juice reinfusion via jejunostomy in patients with gastrointestinal motility disorders or obstruction [11]. When gastric juice is combined with EN formula and returned to the digestive tract, this approach recapitulates a more physiological digestive milieu, thereby facilitating efficient absorption of macronutrients and micronutrients. Furthermore, such reinfusion augments splanchnic blood flow, stimulates enteric neural reflexes and hormonal secretion, preserves the ecological niche of the gut microbiome, reinforces intestinal immune homeostasis, and sustains mucosal barrier integrity, collectively curtailing bacterial translocation [10]. Accumulating evidence indicates that gastric juice reinfusion promotes effective digestion and assimilation of EN, attenuates the severity of gastrointestinal dysfunction, reduces therapy-related adverse events, optimizes nutritional efficacy, and expedites convalescence [12]. Nonetheless, the conventional open reinfusion system necessitates substantial manual handling, is operationally cumbersome, and confers a non-negligible risk of exogenous contamination and subsequent gastrointestinal infection [13].

Building upon these established techniques, we have devised a closed autologous gastric juice reinfusion system specifically tailored for septic patients with concurrent gastrointestinal dysfunction. Although the theoretical benefits of gastric juice reinfusion are well recognized, the safety and clinical efficacy of a *closed* system in the unique pathophysiological context of sepsis—characterized by heightened inflammatory responses and fragile haemodynamic stability—remain largely unexplored. Accordingly, this study was undertaken to evaluate whether the adjunctive application of closed autologous gastric juice reinfusion, in combination with standard EN, improves nutritional tolerance, modulates immune function, and ultimately confers a survival advantage in this high-risk cohort.

Methods

Study design and population

This single-center, retrospective cohort study was conducted at The People's Hospital of Guangxi Zhuang Autonomous Region. We enrolled 95 patients with sepsis and concurrent gastrointestinal dysfunction who were admitted to the intensive care unit (ICU) between January 2024 and June 2025. The cohort comprised 44 patients who received closed autologous gastric juice reinfusion combined with enteral nutrition (EN) (reinfusion group) and 51 patients managed with EN alone (control group).

The study protocol was approved by the institutional ethics committee. Given the retrospective observational design, the requirement for written informed consent specifically for study participation was waived. Nevertheless, as the reinfusion procedure constituted a component of routine clinical practice, written informed consent for the intervention itself had been obtained from all patients or their legally authorized representatives prior to its initiation.

Inclusion criteria

Patients were eligible for inclusion if they met all of the following criteria:

1. Confirmed diagnosis of sepsis with acute gastrointestinal injury (AGI) grade $\geq$ II, and assessed as suitable for EN;
2. Daily volume of gastrointestinal fluid loss $\geq$ 250 mL;
3. No identical pathogen isolated from concurrent blood and gastric juice cultures.

Exclusion criteria

Patients were excluded if any of the following conditions were present:

1. Gastrointestinal ischaemia or necrosis;
2. Complete gastrointestinal obstruction;
3. Massive gastrointestinal haemorrhage (estimated blood loss $\geq$ 400 mL);
4. Positive concordance of pathogens between blood and gastric juice cultures;
5. Contraindications to EN;
6. Inability to achieve nasojejunal tube placement;
7. Withdrawal or refusal of informed consent for the clinical reinfusion procedure.

Data collection

Clinical and laboratory parameters were systematically recorded at baseline (day 0) and on days 1, 3, and 7 post-enrolment. The collected variables encompassed disease severity, assessed by the Acute Physiology and Chronic Health Evaluation II (APACHE II) and Sequential Organ Failure Assessment (SOFA) scores; enteral nutrition tolerance, quantified by a standardized symptom-based scoring system; and routine haematological and biochemical indices, including arterial blood pH, serum sodium (Na^+), potassium (K^+), glucose (Glu), haemoglobin (Hb), and peripheral lymphocyte count (LYC). Additionally, ICU length of stay and 28-day survival status were documented for each patient.

Intervention: closed autologous gastric juice reinfusion

The technical setup of the closed autologous gastric juice reinfusion system is illustrated in Fig. 1. In brief, gastric juice was continuously aspirated via an indwelling nasogastric tube into a sterile, closed collection container, followed by in-line filtration. The filtrate was then reinfused in combination with the EN formula through a nasojejunal tube, thereby establishing a closed circuit designed to minimise exogenous contamination while preserving the biological activity of endogenous digestive enzymes and electrolytes.

The reinfusion procedure was initiated at a flow rate of 5–10 mL/h, which was subsequently titrated upward in 5 mL/h increments as clinically tolerated, based on the patient's abdominal symptoms and gastric residual volume. To maintain enzymatic stability, the collected juice was reinfused within 4 hours

of aspiration, at ambient temperature or under controlled mild warming (with strict avoidance of supra-physiological temperatures that could induce enzyme denaturation).

A rigorous quality-assurance protocol was implemented, comprising real-time visual inspection, routine pH monitoring, and baseline microbiological culture of the initial gastric juice sample. Reinfusion was permitted to continue only upon confirmation of negative culture results, thereby establishing a critical safety threshold. All procedures were executed by trained intensive care nursing staff, with continuous bedside monitoring of vital signs, hourly gastric output, stool characteristics, and overt clinical indicators of feeding intolerance throughout the reinfusion period

Statistical analysis

Continuous variables are expressed as mean $\pm$ standard deviation (SD), and categorical variables as frequencies and percentages. Linear regression models were used to examine the associations between reinfusion and biological indicators at each time point. Linear mixed-effects models were applied to assess the overall longitudinal associations over the entire observation period, accounting for repeated measurements. Logistic regression was used to evaluate the association between reinfusion and 28-day mortality. All models were adjusted for sex, age, surgical history, history of hypertension, diabetes mellitus, and coronary heart disease. A two-sided $P < 0.05$ was considered statistically significant. Analyses were performed using R software (version 4.2.0).

Results

Baseline characteristics

A total of 95 patients with sepsis-related gastrointestinal dysfunction were enrolled in this study. The overall cohort was predominantly male ($n = 72$, 75.8%), with a mean age of 56.9 ± 17.7 years. Baseline comorbidities included hypertension ($n = 41$, 43.2%), diabetes mellitus ($n = 19$, 20.0%), and coronary heart disease ($n = 7$, 7.4%); nine patients (9.5%) had a history of prior surgery.

According to the treatment allocation, 44 patients (46.3%) received closed autologous gastric juice reinfusion combined with enteral nutrition (reinfusion group), whereas the remaining 51 patients (53.7%) received enteral nutrition alone (control group). As summarized in Table 1, the two groups were well balanced with respect to demographic characteristics, underlying comorbidities, and baseline disease severity scores (APACHE II and SOFA), with no significant between-group differences identified (all $P > 0.05$).

Table 1.Demographic characters of this study population	
Characters	Mean $\pm$ SD/n(%)
Gender	
Man	72 (75.79)
Famale	23 (24.21)
Age	56.89 $\pm$ 17.70
Surgical history	
Yes	9 (9.47)
No	86 (90.53)
History of hypertension	
Yes	41 (43.16)
No	54 (56.84)
History of diabetes	
Yes	19 (20.00)
No	76 (80.00)
History of coronary heart disease	
Yes	7 (7.37)
No	88 (92.63)
Gastric juice reinfusion	
Yes	44 (46.32)
No	51 (53.68)
28-day survival outcome	
Death	25 (73.68)
Survive	70 (26.32)

Temporal distribution of biological indicators

Serial changes in disease severity, nutritional tolerance, and key laboratory parameters from baseline (day 0) to day 7 are summarized in Table 2.

Over the 7-day observation period, both groups demonstrated a gradual improvement in illness severity, as reflected by declining APACHE II and SOFA scores. In the overall cohort, the mean APACHE II score

decreased from 19.52 ± 4.21 at day 0 to 17.44 ± 5.96 at day 7, while the SOFA score declined from 8.63 ± 2.98 to 7.79 ± 4.14 over the same interval. The enteral nutrition tolerance score showed a similar pattern, falling from 1.79 ± 1.47 at baseline to its lowest value of 1.37 ± 1.66 on day 1, before rising slightly to 1.68 ± 1.83 by day 7.

Metabolic and haematological indices remained largely stable throughout the study. Arterial blood pH was maintained within the physiological range (approximately 7.44) during the first 3 days, with a mild decline to 7.36 ± 0.77 at day 7. Serum sodium and potassium concentrations stayed within clinically acceptable limits without marked fluctuations. Blood glucose exhibited a progressive reduction from 10.78 ± 5.27 mmol/L at baseline to 9.34 ± 3.86 mmol/L at day 7, whereas haemoglobin levels remained consistently low without appreciable change. Notably, peripheral lymphocyte counts demonstrated a modest upward trajectory, increasing from $1.02 \pm 0.59 \times 10^9$ /L at enrolment to $1.22 \pm 1.28 \times 10^9$ /L by day 7, suggestive of a potential immunomodulatory effect.

Of note, the between-group comparisons for each time point and the corresponding interaction effects are detailed in subsequent sections and in Table 2, which presents the full longitudinal dataset stratified by treatment allocation.

Table 2
Distribution of biological indicators in this study

Indicators	Day0	Day1	Day3	Day7
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD
APACHEII	19.52 ± 4.21	19.21 ± 4.02	18.17 ± 5.10	17.44 ± 5.96
SOFA	8.63 ± 2.98	8.47 ± 2.73	8.24 ± 3.45	7.79 ± 4.14
Enteral nutrition score	1.79 ± 1.47	1.37 ± 1.66	1.53 ± 1.73	1.68 ± 1.83
Ph	7.44 ± 0.08	7.44 ± 0.08	7.44 ± 0.07	7.36 ± 0.77
Na ⁺	142.87 ± 9.30	142.29 ± 8.78	141.50 ± 8.30	139.29 ± 16.38
K ⁺	3.96 ± 0.60	4.02 ± 0.67	4.04 ± 0.70	3.95 ± 0.71
Glu	10.78 ± 5.27	10.11 ± 4.01	9.25 ± 3.38	9.34 ± 3.86
Hb	78.77 ± 23.22	77.41 ± 22.16	78.07 ± 20.28	77.15 ± 17.41
LYC	1.02 ± 0.59	1.05 ± 0.56	1.06 ± 0.60	1.22 ± 1.28

Association between reinfusion and clinical-laboratory indicators (linear regression)

Multivariable linear regression analyses were performed to evaluate the independent associations between closed autologous gastric juice reinfusion and serial clinical-laboratory parameters, adjusting

for age, sex, surgical history, hypertension, diabetes, and coronary heart disease. The full regression outputs are presented in Table 3.

Table 3

The associations between gastric juice reinfusion and biological indicators, using linear regression model

indicators	day0	day1	day3	day7
	β (95%CI)	β (95%CI)	β (95%CI)	β (95%CI)
APACHEII	-0.98 (-2.87, 0.91)	-1.17 (-2.96, 0.62)	-1.56 (-3.78, 0.66)	-2.94 (-5.49, -0.38)*
SOFA	-1.30 (-2.59, -0.003)*	-1.37 (-2.55, -0.18)*	-1.64 (-3.16, -0.12)*	-3.26 (-5.00, -1.52)***
Enteral nutrition score	-0.96 (-1.57, -0.35)**	-0.32 (-1.07, 0.43)	-0.22 (-0.98, 0.54)	-0.15 (-0.96, 0.67)
ph	0.02 (-0.01, 0.06)	0.01 (-0.26, 0.05)	0.02 (-0.01, 0.05)	0.27 (-0.06, 0.59)
Na+	-5.72 (-9.69, -1.75)**	-5.88 (-9.67, -2.09)**	-5.64 (-9.14, -2.15)**	1.85 (-5.43, 9.13)
K+	0.19 (-0.08, 0.44)	0.27 (-0.02, 0.57)	-0.25 (-0.55, 0.05)	0.11 (-0.18, 0.41)
Glu	-0.91 (-3.01, 1.18)	-0.56 (-2.24, 1.11)	0.23 (-1.26, 1.73)	0.14 (-1.55, 1.83)
Hb	-2.75 (-12.79, 7.30)	-1.93 (-11.51, 7.65)	-0.45 (-9.23, 8.33)	-0.81 (-8.36, 6.73)
LYC	0.20 (-0.07, 0.47)	0.20 (-0.05, 0.45)	0.26 (0.0002, 0.53)*	0.09 (-0.49, 0.67)
Note: Adjusted for gender, age, surgical history, history of hypertension, history of diabetes and history of coronary heart disease. * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.				

Disease severity scores. Reinfusion was significantly and inversely associated with SOFA scores across all four time points, with progressively stronger effect sizes over time (Day 0: $\beta = -1.30$, 95% CI – 2.59 to – 0.003, $P < 0.05$; Day 1: $\beta = -1.37$, 95% CI – 2.55 to – 0.18, $P < 0.05$; Day 3: $\beta = -1.64$, 95% CI – 3.16 to – 0.12, $P < 0.05$; Day 7: $\beta = -3.26$, 95% CI – 5.00 to – 1.52, $P < 0.001$). It should be noted, however, that a significant between-group difference in SOFA was already present at baseline, reflecting the inherent imbalance characteristic of this retrospective cohort. In contrast, for APACHE II scores, a statistically significant inverse association with reinfusion emerged only at Day 7 ($\beta = -2.94$, 95% CI – 5.49 to – 0.38, $P < 0.05$), with no significant associations detected at earlier time points.

Nutritional tolerance and electrolyte balance. Reinfusion was negatively associated with enteral nutrition tolerance score at baseline (Day 0: $\beta = -0.96$, 95% CI -1.57 to -0.35 , $P < 0.01$), but this association did not persist on subsequent days (all $P > 0.05$). Serum sodium exhibited significant inverse relationships with reinfusion at Days 0, 1, and 3 (all $P < 0.01$; detailed estimates in Table 3), which attenuated by Day 7. No significant associations were observed between reinfusion and serum potassium, arterial pH, or blood glucose at any time point, with all effect estimates showing small magnitudes and wide confidence intervals encompassing the null.

Immunological and haematological parameters. A modest but statistically significant positive association between reinfusion and peripheral lymphocyte count was identified at Day 3 ($\beta = 0.26$, 95% CI $0.0002-0.53$, $P < 0.05$), although the lower bound of the confidence interval approximated zero, warranting cautious interpretation. No significant associations were found for haemoglobin levels throughout the study period, suggesting that the intervention did not appreciably affect erythropoietic or haemodilutional status.

Association with 28-day survival

Multivariable logistic regression analysis, adjusted for the same covariates as the linear regression models (age, sex, surgical history, hypertension, diabetes, and coronary heart disease), demonstrated that closed autologous gastric juice reinfusion was independently associated with a substantially lower odds of 28-day mortality (odds ratio [OR] = 0.07 , 95% confidence interval [CI] $0.02-0.29$, $P < 0.001$), corresponding to a 93% relative risk reduction in the adjusted model (Table 4).

Table 4
The associations between gastric juice reinfusion and 28-day survival outcome, using logistic regression model

Indicator	OR (95%CI)
28-day survival outcome	$0.07 (0.02, 0.29)^{***}$
Note: Adjusted for gender, age, surgical history, history of hypertension, history of diabetes and history of coronary heart disease. $^*P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$.	

Longitudinal associations (linear mixed-effects models)

Linear mixed-effects models were applied to evaluate the overall longitudinal associations between closed autologous gastric juice reinfusion and repeated measurements of clinical-laboratory parameters across the 7-day observation period, after adjustment for the same covariate set. The full model outputs are presented in Table 5.

Disease severity. Reinfusion exerted a significant and sustained protective effect on both illness severity scores throughout the study period, as evidenced by negative longitudinal coefficients for APACHE II ($\beta = -1.66$, 95% CI -2.71 to -0.61 , $P < 0.01$) and SOFA scores ($\beta = -1.89$, 95% CI -2.59 to -1.19 , $P < 0.001$).

Nutritional and electrolyte parameters. A significant inverse longitudinal association was observed between reinfusion and enteral nutrition tolerance score ($\beta = -0.41$, 95% CI -0.77 to -0.05 , $P < 0.05$), indicating improved feeding tolerance in the intervention group over time. Serum sodium concentrations were also negatively correlated with reinfusion across the entire follow-up ($\beta = -3.85$, 95% CI -6.28 to -1.42 , $P < 0.01$), although levels remained within clinically acceptable ranges as noted in the temporal analysis.

Immunological and haematological parameters. Peripheral lymphocyte count demonstrated a modest but statistically significant positive longitudinal association with reinfusion ($\beta = 0.19$, 95% CI 0.01 – 0.37 , $P < 0.05$), suggesting a potential immunoenhancing effect. In contrast, no significant longitudinal associations were detected for arterial pH, serum potassium, blood glucose, or haemoglobin levels across the 7-day period, with all effect estimates showing small magnitudes and confidence intervals encompassing the null value (Table 5).

Collectively, these longitudinal findings corroborate the time-point-specific regression results, reinforcing the consistent benefit of closed autologous gastric juice reinfusion in improving disease severity, nutritional tolerance, and lymphocyte-mediated immunity over the course of treatment.

Table 5

The associations between gastric juice reinfusion and biological indicators, using linear mixed model

Indicators	β (95%CI)
APACHEII	-1.66 (-2.71, -0.61)**
SOFA	-1.89 (-2.59, -1.19)***
Enteral nutrition score	-0.41 (-0.77, -0.05)*
ph	0.08 (-0.005, 0.16)
Na+	-3.85 (-6.28, -1.42)**
K+	0.08 (-0.07, 0.22)
Glu	-0.28 (-1.17, 0.60)
Hb	-1.49 (-5.85, 2.86)
LYC	0.19 (0.01, 0.37)*
Note: Adjusted for gender, age, surgical history, history of hypertension, history of diabetes and history of coronary heart disease. * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.	

Discussion

In this single-center retrospective cohort study, the addition of closed autologous gastric juice reinfusion to standard enteral nutrition was associated with significantly improved nutritional tolerance, attenuated disease severity as reflected by APACHE II and SOFA scores, enhanced peripheral lymphocyte counts, and a substantially lower 28-day mortality rate among septic patients with gastrointestinal dysfunction. Collectively, these findings suggest that this closed-circuit technique may serve as a safe and feasible adjunctive strategy to preserve gastrointestinal homeostasis and facilitate effective EN delivery in this high-risk population.

The physiological rationale underlying this intervention lies in the compositional complexity of gastric juice, which contains a rich array of electrolytes, digestive enzymes, and peptide hormones essential for normal digestion and absorption [14]. In septic patients requiring gastrointestinal decompression, the loss of these endogenous fluids through nasogastric drainage can perpetuate electrolyte disturbances and acid-base imbalances, further compromising nutritional status and delaying recovery. By returning autologous gastric juice via a closed system, we effectively replenished water, electrolytes, and enzymatic activity, thereby preserving intestinal mucosal integrity, stimulating gastrointestinal motility, and enhancing tolerance to EN. This mechanistic framework is consistent with previous reports demonstrating that gastric juice reinfusion reduces gastrointestinal complications and improves nutritional outcomes in critically ill populations [15, 16].

The observed improvements in SOFA and APACHE II scores in the reinfusion group align with the findings of Zhang et al. [15], who reported higher serum albumin, total protein, and haemoglobin levels, alongside lower complication rates, in ICU patients receiving gastric juice reinfusion with early EN. We posit that this benefit is plausibly mediated through preservation of the intestinal epithelial barrier [17], reduction of bacterial translocation, and consequent attenuation of the systemic inflammatory response—three interconnected pathways that are critically implicated in sepsis-induced multiple organ dysfunction.

The significantly lower enteral nutrition tolerance score in the reinfusion group, consistently observed in both cross-sectional and longitudinal analyses, corroborates the meta-analytic conclusions of Chen et al. [18], who found that autologous gastric juice reinfusion reduces adverse gastrointestinal events—including diarrhoea, vomiting, abdominal distension, and constipation—thereby promoting the attainment of nutritional targets. Similarly, Wang et al. [19] documented reduced incidences of electrolyte disturbances and gastrointestinal symptoms in ICU patients managed with this technique. Notably, while serum sodium levels were modestly lower in the reinfusion group throughout the study period, they consistently remained within clinically acceptable physiological ranges, suggesting that the closed system maintains electrolyte homeostasis with sufficient precision, avoiding both depletion and overcorrection.

From an immunological perspective, the positive association between reinfusion and lymphocyte counts deserves particular attention. Lymphopenia is a well-recognized hallmark of sepsis-induced immunosuppression, and its persistence correlates with adverse outcomes. The observed lymphocyte

recovery in the reinfusion group may reflect a convergence of improved nutritional status, reduced systemic inflammation, and preserved gut-associated lymphoid tissue (GALT) function—all of which are interdependent and likely contribute to the survival benefit we observed. Whether this effect is directly attributable to the preservation of GALT-derived lymphocyte trafficking or secondary to improved overall clinical status warrants further investigation.

Our reinfusion protocol incorporated several quality-assurance measures—including strict aseptic collection, timely infusion within 4 hours of aspiration, controlled temperature management to preserve enzymatic activity, and gradual rate titration based on clinical tolerance—which were integral to ensuring procedural safety and reproducibility. These operational parameters, adapted from previous experience [20, 21], likely minimized contamination risk while maximizing the therapeutic yield of the technique.

Although earlier investigations have examined digestive juice reinfusion in patients with intestinal fistulas or postsurgical conditions [22–24], robust evidence specifically addressing septic patients with concurrent gastrointestinal dysfunction remains scarce. Furthermore, the majority of previous studies employed open systems[25, 26], which are operator-dependent, resource-intensive, and confer a non-negligible risk of exogenous contamination. Our closed-circuit approach directly addresses these limitations, offering a standardized, reproducible protocol that can be feasibly implemented in routine intensive care practice.

Limitations

This study has several limitations. First, it is a single-center retrospective design, which may introduce selection bias and limit generalizability. Second, the sample size is relatively small, and unmeasured confounders may exist despite multivariable adjustment. Third, the mechanism underlying the immune benefit—whether direct or indirect—warrants further investigation. Fourth, we did not assess long-term outcomes beyond 28 days. Prospective randomized controlled trials are needed to confirm our findings and to establish optimal patient selection, timing, and dosing protocols.

Conclusions

Several limitations of this study warrant acknowledgment. First, the single-center, retrospective design inherently limits generalizability and introduces potential selection bias, despite multivariable adjustment for prespecified confounders. Second, the modest sample size ($n = 95$) may have reduced statistical power to detect smaller effect sizes, particularly for secondary outcomes. Third, the non-randomized allocation precludes definitive causal inference; residual confounding by unmeasured variables (e.g., disease severity at presentation, variations in clinical practice) cannot be entirely excluded. Fourth, the 7-day observation window may be insufficient to capture longer-term nutritional and immunological outcomes. Finally, the single-institution nature of the protocol raises questions about reproducibility across different healthcare settings, and the generalizability of our findings to non-Asian populations remains uncertain. Future prospective, multicenter, randomized controlled trials are therefore warranted

to validate these findings and establish the optimal patient selection criteria and infusion protocols for this promising adjunctive therapy.

Declarations

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee of Guangxi Zhuang Autonomous Region People's Hospital (No. KY-IIT-2023-20). and was conducted in accordance with the principles outlined in the Declaration of Helsinki and in compliance with relevant laws and institutional guidelines. All participants provided written informed consent. Consent for publication Not applicable. Competing interests The authors declare no competing interests.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests

Funding

This study was supported by the Guangxi Medical and Health Appropriate Technology Development and Promotion Project (Grant No. S2022017), the Science and Technology Project of Guangxi Zhuang Autonomous Region Center for Disease Control and Prevention (Grant No. GXJJKJ2026YB017), and the Science and Technology Project of Guangxi Zhuang Autonomous Region Center for Disease Control and Prevention (Grant No. GXJJKJ2025ZD004). The funding bodies played no role in the design of the study, the collection, analysis, and interpretation of data, or the writing of the manuscript.

Author Contribution

Huirong Shi (cohort designing/ sampling/ writing/reviewing), Xiao Gang Wang, Lin Han (data collection/ analysis), Fang Liu, Li Lan, Jinyan Tang (data collection and assembly), Jing Pang, Shulin Xiang, Bin Xiong (study design, data acquisition/ analysis, supervision, writing, revision and final approval). All authors reviewed the manuscript.

Acknowledgement

This work was supported by the Guangxi Medical and Health Appropriate Technology Development and Promotion Project (Grant No. S2022017), the Science and Technology Project of Guangxi Zhuang Autonomous Region Center for Disease Control and Prevention (Grant No. GXJKKJ2026YB017), and the Science and Technology Project of Guangxi Zhuang Autonomous Region Center for Disease Control and Prevention (Grant No. GXJKKJ2025ZD004). The funding bodies played no role in the design of the study, the collection, analysis, and interpretation of data, or the writing of the manuscript.

Data Availability

The datasets generated and analysed during the present study are not publicly available due to patient privacy and ethical restrictions, but are available from the corresponding author upon reasonable request.

References

1. Rudd KE, Johnson SC, Agesa KM, et al. Global, regional, and national sepsis incidence and mortality, 1990–2017: analysis for the Global Burden of Disease Study. *Lancet*. 2020;395:200–11. 10.1016/S0140-6736(19)32989-7.
2. Fleischmann–Struzek C, Mellhammar L, Rose N, et al. Incidence and mortality of hospital– and ICU–treated sepsis: results from an updated and expanded systematic review and meta–analysis. *Intensive Care Med*. 2020;46:1552–62. 10.1007/s00134-020-06151-x.
3. Singer M, Deutschman CS, Seymour CW, et al. The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis–3). *JAMA*. 2016;315:801–10. 10.1001/jama.2016.0287.
4. Reintam Blaser A, Preiser JC, Fruhwald S, et al. Gastrointestinal dysfunction in the critically ill: a systematic scoping review and research agenda proposed by the Section of Metabolism, Endocrinology and Nutrition of the European Society of Intensive Care Medicine. *Crit Care*. 2020;24:224. 10.1186/s13054-020-02889-4.
5. Reintam Blaser A, Malbrain ML, Starkopf J, et al. Gastrointestinal function in intensive care patients: terminology, definitions and management. Recommendations of the ESICM Working Group on Abdominal Problems. *Intensive Care Med*. 2012;38:384–94. 10.1007/s00134-011-2459-y.
6. Lambell KJ, Tatucu–Babet OA, Chapple LA, Gantner D, Ridley EJ. Nutrition therapy in critical illness: a review of the literature for clinicians. *Crit Care*. 2020;24:35. 10.1186/s13054-020-2739-4.
7. Reintam Blaser A, Starkopf J, Alhazzani W, et al. Early enteral nutrition in critically ill patients: ESICM clinical practice guidelines. *Intensive Care Med*. 2017;43:380–98. 10.1007/s00134-016-4665-0.
8. van Zanten ARH, De Waele E, Wischmeyer PE. Nutrition therapy and critical illness: practical guidance for the ICU, post–ICU, and long–term convalescence phases. *Crit Care*. 2019;23:368. 10.1186/s13054-019-2657-5.
9. Hu B, Sun R, Wu A, et al. Severity of acute gastrointestinal injury grade is a predictor of all–cause mortality in critically ill patients: a multicenter, prospective, observational study. *Crit Care*.

- 2017;21:188. 10.1186/s13054-017-1780-4.
10. Jiang FZ, Song XL, Zhao XC, et al. Nursing of segmental enteral nutrition combined with digestive juice reinfusion in patients with multiple intestinal fistulas. *J Nurs PLA*. 2015;32:39–42. 10.3969/j.issn.1008-9993.2015.12.011.
 11. Wolfer JA. Jejunostomy with jejunal alimentation. *Ann Surg*. 1935;101:708–25. 10.1097/00000658-193502000-00006.
 12. Jiang FZ, Zhou J, Ye XH. Progress in methods and nursing of digestive juice reinfusion. *J Nurs PLA*. 2013;30:33–6. 10.3969/j.issn.1008-9993.2013.20.010.
 13. Deng PY. Promoting effect and nursing of gastric juice reinfusion on recovery of gastrointestinal function after abdominal surgery. *North Pharm J*. 2011;8:112–3. DOI:10. 15887/j. cnki. 13-1389/r. 2015. 18. 085.
 14. Zhu JG, Wang J, He Y, Zhuang HW, Yang JY. Application of double small–intestinal stoma and intestinal fluid reinfusion in patients with severe intra–abdominal infection. *Chin J Gastrointest Surg*. 2015;18:667–70. 10.3760/cma.j.issn.1671-0274.2015.07.009.
 15. Zhang YM. Effect of gastric juice reinfusion in early enteral nutrition support in ICU patients. *Nurs Pract Res*. 2019;16:148–9. 10.3969/j.issn.1672-9676.2019.21.063.
 16. Ye X, Peng N, Jiang F, et al. Subsegmental bowel enteral nutrition infusion and succus entericus reinfusion in patients with severe acute pancreatitis complicated with multiple enteric fistulae: a successful experience. *Am Surg*. 2013;79:E169–71. doi.org/10.1177/000313481307900415.
 17. Ye XH, Wang XY, Peng NH, Jiang FZ, Li WQ. Methods and experience in collection and reinfusion of digestive juice. *Parenter Enter Nutr*. 2008;15:61–264. 10.3969/j.issn.1007-810X.2008.01.019.
 18. Chen X, Yu YF, Feng CC, Qin Y, Wang M. Meta–analysis of the effect of autologous gastric juice reinfusion in patients with enteral nutrition support. *Evid–Based Nurs*. 2023;9:997–1002. 10.12102/j.issn.2095-8668.2023.06.008.
 19. Wang HY, Yan DB, Liu WW, Duan ML. Effect of gastric juice reinfusion on enteral nutrition support in ICU patients. *World Chin J Dig*. 2016;24:947–51. 10.11569/wcjd.v24.i6.947.
 20. Ding SM. Effect and nursing analysis of autologous gastric juice reinfusion in nutritional support of patients undergoing abdominal surgery. *Med Theory Pract*. 2019;32:4067–8. 10.19381/j.issn.1001-7585.2019.24.073.
 21. Virani FR, Peery T, Rivas O, et al. Incidence and effects of feeding intolerance in trauma patients. *JPEN J Parenter Enter Nutr*. 2019;43:742–9. 10.1002/jpen.1469.
 22. Zuo M, Xia S, Liu J, et al. Digestive fluid reinfusion via nasojejunal tube improved dyspepsia after a primary anastomosis in intestinal atresia. *Adv Neonatal Care*. 2025;25:441–6. 10.1097/ANC.0000000000001291.
 23. Kumar N, Karn S, Goswami AG, et al. Distal infusion stomal enteroclysis: An effective technique to manage postoperative enterostomal output. *J Visc Surg*. 2025;162:13–8. 10.1016/j.jviscsurg.2024.11.002.

24. Diao N, Zheng W, Chen H, Tang J. Exclusive enteral nutrition combined with continuous succus entericus reinfusion for high-output stoma in patients with Crohn's disease: a case report. *Gastroenterol Rep.* 2024;12:goae100. 10.1093/gastro/goae100.
25. Zhou MY, Qing M, Yao HL, Zhao ZH, Yu SS. Nursing study on segmental enteral nutrition combined with digestive juice reinfusion to improve nutritional status of patients with severe intestinal fistula. *Parenter Enter Nutr.* 2024;31:162–6. 10.16151/j.1007-810x.2024.03.006.
26. Gu XY, Li P. Nursing of a patient with superior mesenteric artery compression syndrome receiving enteral nutrition. *Chin J Nurs.* 2016;51:1023–4. 10.3761/j.issn.0254-1769.2016.08.028.

Figures

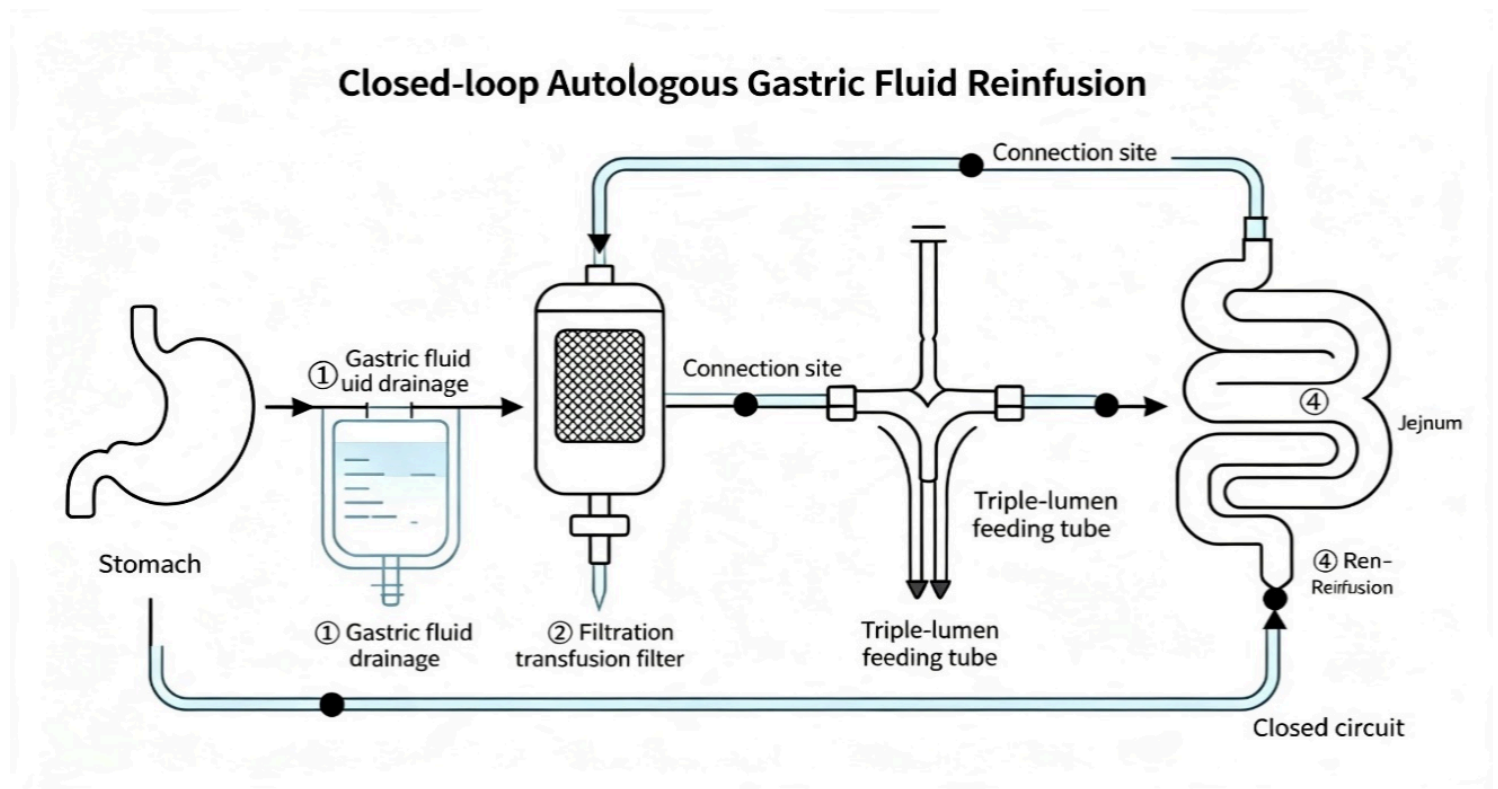


Figure 1

Schematic illustration of the closed autologous gastric juice reinfusion setup, outlining the key procedural steps from aspiration to reinfusion