ORIGINAL RESEARCH

The Impact of Ultrasound-Guided Combined with Water and Air Mixed Injection Method for Nasal Intestinal Tube Placement on Gastrointestinal Burden in Patients with Severe Acute Pancreatitis

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ABSTRACT

Objective • This study aims to investigate the impact of ultrasound-guided combined with water and air mixed injection method for nasal intestinal tube placement on gastrointestinal burden in patients with severe acute pancreatitis.

Methods • A cohort of 116 patients with severe acute pancreatitis admitted to the hospital from August 2021 to July 2023 were included. They were randomly divided into the control group (58 cases, nasal intestinal tube placement using ultrasound-guided combined water injection) and the observation group (58 cases, nasal intestinal tube placement using ultrasound-guided combined with water and air mixed injection). The incubation time, volume of water injected during the incubation, nasal intestinal tube visualization rate, and success rate of one-time incubation were recorded for both groups. Gastrointestinal mucosal barrier function, Nutritional index level including intestinal fatty acid-binding protein (I-FABP), D-lactate and nutritional index levels including hemoglobin (Hb), serum albumin (ALB), retinol-binding protein (RBP) were compared between the two groups before tube placement and at 7 days after incubation. Complications in both groups were also recorded.

Results • The incubation time in the observation group was shorter, and the volume of water injected during the incubation was lower than in the control group. The nasal intestinal tube visualization rate and success rate of one-time incubation were higher in the observation group ($P < .05$). At 7 days after incubation, the levels of I-FABP and D-lactate were lower in the observation group than in the control group ($P < .05$). At 7 days after incubation, The levels of I-FABP and D-lactate in the observation group were lower than those in the control group, Hb and RBP levels were higher in the observation group than in the control group ($P < .05$), while there was no significant difference in ALB levels between the two groups ($P > .05$). The incidence of complications was lower in the observation group than in the control group ($P < .05$).

Conclusion • Ultrasound-guided combined with water and air mixed injection method for nasal intestinal tube placement in patients with severe acute pancreatitis can shorten the incubation time, reduce the volume of water injected during the incubation, improve the nasal intestinal tube visualization rate and success rate of one-time incubation, enhance gastrointestinal mucosal barrier function and nutritional index in patients, and reduce the incidence of complications. (*Altern Ther Health Med.* 2024;30(12):424-429).

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INTRODUCTION

Severe acute pancreatitis is a clinically common acute abdominal condition that involves multiple systemic and organ changes in the body. Patients often experience renal, circulatory, and respiratory failure due to persistent systemic inflammatory response syndrome. It can also lead to increased intra-abdominal pressure and gastrointestinal dysfunction.[1,2] Severe pancreatitis typically has a sudden onset, poses a serious threat to health, and carries a high mortality rate.[3] Studies have indicated that early enteral nutrition can improve the nutritional status of patients with severe pancreatitis, reduce endotoxin levels, prevent gastrointestinal mucosal atrophy, protect intestinal barrier function, and promote patient recovery.[4,5] Currently, the primary method for early enteral nutrition is the nasal intestinal tube, and ultrasound, with its simplicity, lack of radiation, and visualization capabilities, is widely used for nasal intestinal tube placement. However, ultrasound images can be affected by factors such as intestinal edema and gas, making it difficult to monitor the real-time dynamic position of the nasal intestinal tube tip. Previous research has indicated that injecting water and air into the nasal intestinal tube can enhance echoes and improve the visualization of the nasal intestinal tube under ultrasound guidance.[6] However, excessive injection of water or air may exacerbate gastrointestinal bloating and edema in patients with severe pancreatitis, leading to increased artifacts and enhanced echoes, which can affect the quality of observation. The objective of this study is to compare the use of ultrasound-guided combined with water and air mixed injection with ultrasound-guided water injection alone for nasal intestinal tube placement and to evaluate the efficacy and feasibility of ultrasound-guided combined with water and air mixed injection for nasal intestinal tube placement. The results are reported as follows.

MATERIALS AND METHODS

General Information

The study was reviewed and approved by the hospital ethics committee. A cohort of 116 patients with severe acute pancreatitis admitted to the hospital from August 2021 to July 2023 were included in this study. They were randomly divided into the control group (58 cases, nasal intestinal tube placement using ultrasound-guided water injection) and the observation group (58 cases, nasal intestinal tube placement using ultrasound-guided combined water and air mixed injection) using a random number table. There were no significant differences in gender, age, body mass index, and Acute Physiology and Chronic Health Evaluation II (APACHE II) scores between the two groups, indicating good baseline comparability ($P > .05$).

Inclusion and Exclusion Criteria

Inclusion Criteria: (1) Meeting the diagnostic criteria for severe acute pancreatitis[7]; (2) Inability to orally ingest food and requiring enteral nutrition support therapy; (3) Normal coagulation function; (4) Informed consent from the patient or their family members and willingness to cooperate with the study.

Exclusion Criteria: (1) History of previous gastrointestinal surgery; (2) Concurrent mechanical intestinal obstruction; (3) Concurrent severe gastrointestinal infectious diseases; (4) Concurrent congenital metabolic disorders; (5) Concurrent malignant tumors, liver or kidney dysfunction, or other severe illnesses; (6) Facial fractures preventing nasal intestinal tube placement; (7) Ineffective treatment leading to patient mortality.

Methods

Instruments, Materials, and Tube Placement Procedure. The following instruments and materials were used in this study: a Sonosite bedside ultrasound machine, Flocare nasal intestinal tube (Model: CH10, Material: Polyurethane, Inner diameter: 2.00-2.10 mm, Outer diameter: 3.23-3.38 mm, Length: 130 cm), treatment bowls, treatment trays, sterile gloves, stethoscope, 20 ml sterile syringes, sterile injection water, and 300 ml warm water. The placement of the nasal intestinal tube was performed collaboratively by two operators who had received training in critical care ultrasound from the Chinese Critical Care Ultrasound Research Group and held valid certificates. One operator was responsible for bedside ultrasound examination, while the other operator was responsible for placing the nasal intestinal tube. Both operators closely monitored changes in the ultrasound images throughout the entire procedure.

Pre-tube Placement Preparation

Nasal Intestinal Tube Preparation: The operator wears sterile gloves and places a sterile treatment tray. Warm water is poured into the treatment bowl, and the front end of the nasal intestinal tube is placed in sterile injection water to lubricate the tube pathway. The handle of the guiding wire is inserted into the nasal intestinal tube, and 25 ml of sterile injection water is injected into the tube through the guiding wire.

Ultrasound Assessment: Detailed ultrasound examination is conducted to assess the patient's gastric antrum in both cross-sectional and longitudinal views, evaluating the position, size, and filling degree of the gastric antrum.

Patient Preparation: The patient is positioned on their side, with the head of the bed elevated at an angle of 30-45 degrees to aid in gastric decompression and ensure effective drainage of gastric contents.

Control Group

In the control group, ultrasound-guided water injection was used for nasal intestinal tube placement. Thirty minutes before the procedure, the patient was given a 10 mg intramuscular injection of metoclopramide (produced by Sinopharm Group Rongsheng Pharmaceutical Co., Ltd., SFDA approval number: H20023103, specification: 1 ml). The nasal intestinal tube was slowly inserted into the stomach through one nostril by one operator. When the nasal intestinal tube reached a depth of 55-60 cm, a linear array ultrasound probe (6-13 MHz) was used to examine the patient's neck to confirm the positions of the esophagus, airway, and carotid artery, and to observe the "double-track sign," indicating that the catheter had passed through the pyloric canal and entered the stomach smoothly. When the nasal intestinal tube reached a depth of 65cm, one operator continued to use a convex array ultrasound probe (2-4 MHz) to locate the gastric antrum, rotating the ultrasound probe to find the longitudinal view of the gastric antrum. Meanwhile, another operator administered a 10ml bolus of water and observed whether the catheter was brightly visualized. The ultrasound probe continued to observe the longitudinal view of the gastric antrum while simultaneously gently advancing the catheter, expanding the local intestinal tube by infusing warm water, and ensuring that the catheter advanced smoothly, with a rate of 2-3 cm per minute. If significant resistance was encountered during the advancement of the nasal intestinal tube, it was retracted 5-10 cm until the guide wire was inserted without rebound, and this process was repeated. When the nasal intestinal tube reached a depth of 75 cm, the duodenal bulb was examined using ultrasound, and another 10ml bolus of water was injected to check for catheter visualization. The catheter was then slowly advanced to a depth of 100 cm, and the horizontal portion of the duodenum was examined using ultrasound, with another 10 ml bolus of water administered to check for catheter visualization.

Observation Group

In the observation group, ultrasound-guided combined with water and air mixed injection was used for nasal intestinal tube placement. The tube placement procedure was the same as in the control group, but a 5:5 mixture of water and air was injected. The injection method was the same as in the control group, and under ultrasound guidance, the catheter exhibited a beaded appearance.

Observation Parameters

Tube Placement Parameters: Record the incubation time (the time from the start of nasal intestinal tube placement to completion), volume of water injected during the incubation (the volume of warm water injected during nasal intestinal tube placement), nasal intestinal tube visualization rate (the rate of catheter visualization during ultrasound examination at the horizontal portion of the duodenum, a key site for ultrasound positioning, while injecting water or water-air mixture), success rate of one-time incubation (consider the tip of the nasal intestinal tube entering the horizontal portion of the duodenum as successful placement, and calculate the one-time placement success rate).

Gastrointestinal Mucosal Barrier Function: Collect 4 ml of fasting venous blood from both groups before tube placement and at 7 days after tube placement. Centrifuge at 3500 rpm for 10 minutes, and collect serum. Measure the levels of intestinal fatty acid-binding protein (I-FABP) using a sandwich ELISA method and D-lactate levels using the lactate dehydrogenase method.

Nutritional Index Levels: Collect serum for both groups and measure hemoglobin (Hb), serum albumin (ALB), and retinol-binding protein (RBP) levels using an automated biochemical analyzer，among them, the normal value of Hb is 120-160g/L for males and 110-150g/L for females; Normal value of ALB: 35-50g/L for adults under 60 years old, 34-48g/L for elderly people over 60 years old; Normal RBP values: 36-56mg/L for males and 26.7-57.9mg/L for females.

Complications: Record the occurrence of reflux, accidental inhalation, bloating, and diarrhea in both groups.

Statistical Analysis

Data processing was performed using Statistic Package for Social Science (SPSS) 23.0 software (IBM, Armonk, NY, USA). Measurement data (incubation time, volume of water injected during the incubation, nasal intestinal tube visualization rate, and success rate of one-time incubation, gastrointestinal mucosal barrier function, nutritional index levels) were expressed as "$\bar{x} \pm s$" and analyzed using the *t* test. Enumeration data (complications) were presented as "n (%)" and analyzed using the χ^2 test. Statistical significance was set at $P < .05$ for all analyses.

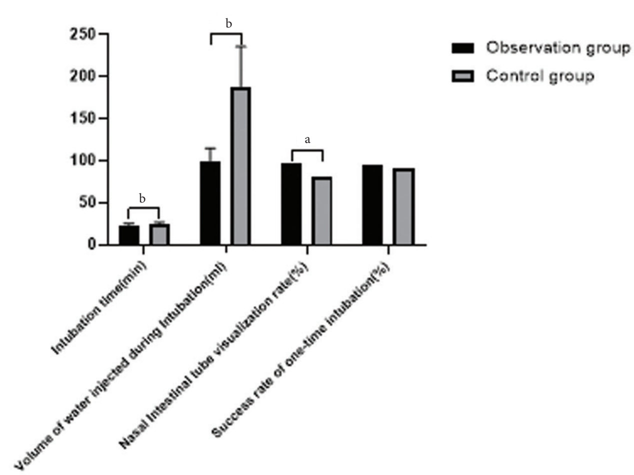
Table 1. Comparison of General Information between the Two Groups

Indicators		Observation Group (n=58)	Control Group (n=58)	Statistical Values	*P* value
Gender (%)	Male	32(55.17)	30(51.72)	χ^2=0.139	.710
	Female	26(44.83)	28(48.28)		
Age ($\bar{x} \pm s$, year)		52.38±5.83	51.84±6.12	*t*=0.487	.628
BMI ($\bar{x} \pm s$, kg/m^2)		24.96±2.17	25.21±2.34	*t*=0.597	.552
White blood cell count ($\bar{x} \pm s$,×10^9/L)		12.85±3.12	12.96±3.36	*t*=0.183	.855
APACHE II score ($\bar{x} \pm s$, points)		18.03±2.42	17.93±2.51	*t*=0.218	.828
Disease types(%)	Biliary pancreatitis	36(62.07)	33(56.90)	χ^2=0.841	.657
	Alcoholic pancreatitis	12(20.69)	11(18.97)		
	Hyperlipidemic pancreatitis	10(17.24)	14(24.14)		

Table 2. Comparison of Incubation Time, Volume of Water Injected during the Incubation, Nasal Intestinal Tube Visualization Rate, and Success Rate of One-time Incubation

Groups	Incubation Time ($\bar{x} \pm s$, min)	Volume of Water Injected during the Incubation ($\bar{x} \pm s$, ml)	Nasal Intestinal Tube Visualization Rate [n(%)]	Success Rate of One-time Incubation [n(%)]
Observation Group (n=58)	22.94±2.31	98.12±16.72	56(96.55)	55(94.83)
Control Group (n=58)	24.86±2.19	186.64±48.96	47(81.03)	53(91.38)
t/χ^2	4.594	13.031	7.017	0.134
P value	<.001	<.001	.008	.714

Figure 1. Comparison of Incubation Time, Volume of Water Injected during the Incubation, Nasal Intestinal Tube Visualization Rate, and Success Rate of One-time Incubation



$^aP < .01$

$^bP < .001$

RESULTS

Comparison of Incubation Time, Volume of Water Injected during the Incubation, Nasal Intestinal Tube Visualization Rate, and Success Rate of One-time Incubation

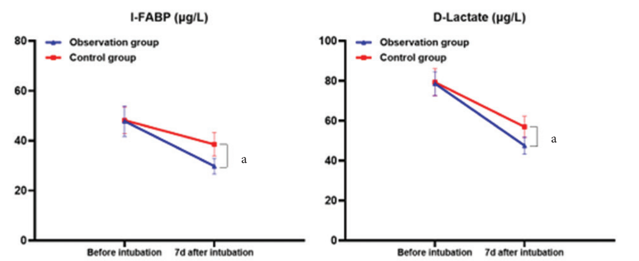
The observation group had a shorter incubation time, a lower volume of water injected during the incubation, a

Table 3. Comparison of Gastrointestinal Mucosal Barrier Function in Both Groups Before and at 7 Days After Incubation ($\bar{x} \pm s$, μg/L)

Groups	I-FABP		D-lactate	
	Before incubation	7 d after incubation	Before incubation	7 d after incubation
Observation Group (n=58)	47.86±6.12	29.82±3.14[a]	78.62±5.94	47.58±4.31[a]
Control Group (n=58)	48.17±5.38	38.56±4.76[a]	79.31±6.79	56.94±5.28[a]
t	0.290	11.623	0.583	10.459
P value	.773	<.001	.561	<.001

[a]Compared with the groups before incubation, $P < .05$

Figure 2. Comparison of Gastrointestinal Mucosal Barrier Function in Both Groups Before and at 7 Days After Incubation



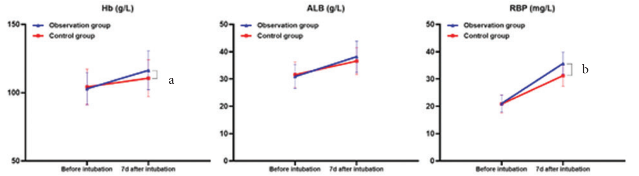
[a]$P < .001$

Table 4. Comparison of Nutritional Index Levels in Both Groups Before and at 7 Days After Incubation ($\bar{x} \pm s$)

Groups	Hb(g/L)		ALB(g/L)		RBP(mg/L)	
	Before incubation	7 d after incubation	Before incubation	7 d after incubation	Before incubation	7 d after incubation
Observation Group (n=58)	102.86±11.79	116.38±14.27[a]	30.92±4.36	38.16±5.72[a]	21.04±3.15	35.68±4.16[a]
Control Group (n=58)	104.25±12.96	110.63±13.56[a]	31.57±4.68	36.58±4.93[a]	20.86±3.27	31.24±3.92[a]
t	0.604	2.225	0.774	1.594	0.302	5.916
P value	.547	.028	.441	.114	.763	.000

[a]Compared with the groups before incubation, $P < .05$

Figure 3. Comparison of Nutritional Index Levels in Both Groups Before and at 7 Days After Incubation



[a]$P < .05$
[b]$P < .001$

higher nasal intestinal tube visualization rate, and a higher success rate of one-time incubation compared to the control group ($P < .05$). (Table 2 and Figure 1)

Comparison of Gastrointestinal Mucosal Barrier Function in Both Groups Before and at 7 Days After Incubation

At 7 days after incubation, the levels of I-FABP and D-lactate were lower in the observation group compared to the control group ($P < .05$). (Table 3 and Figure 2)

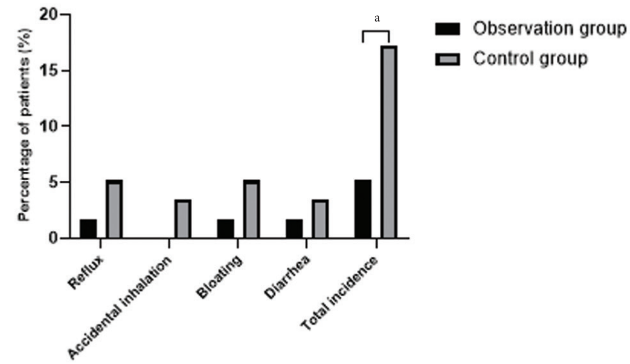
Comparison of Nutritional Index Levels in Both Groups Before and at 7 Days After Incubation

At 7 days after incubation, the levels of Hb and RBP were higher in the observation group compared to the control group ($P < .05$). There was no significant difference in ALB levels between the two groups ($P > .05$). (Table 4 and Figure 3)

Table 5. Comparison of Complications Between the Two Groups, n (%)

Groups	Reflux	Accidental inhalation	Bloating	Diarrhea	Total incidence
Observation Group (n=58)	1(1.72)	0(0.00)	1(1.72)	1(1.72)	3(5.17)
Control Group (n=58)	3(5.17)	2(3.45)	3(5.17)	2(3.45)	10(17.24)
χ^2					4.245
P value					.039

Figure 4. Comparison of the Incidence of Complications Between the Two Groups



[a]$P < .05$

Comparison of Complications Between the Two Groups

The observation group had a lower incidence of complications compared to the control group ($P < .05$). (Table 5 and Figure 4)

DISCUSSION

Patients with severe acute pancreatitis often experience a hypermetabolic state, characterized by processes such as glycogenolysis and fat mobilization. Additionally, they may have impaired gastric motility and gastric emptying function, which make normal oral intake difficult. In a stress state, metabolic rates are increased, leading to higher energy expenditure, and these patients are at risk of developing malnutrition.[8,9] Therefore, providing enteral or parenteral nutritional support is essential. Conventional placement of nasal intestinal tubes in patients can be uncomfortable and challenging, with a low success rate of one-time incubation. This approach can lead to complications such as feeding intolerance and gastric retention, which are not conducive to patient recovery. In contrast, the placement of nasal intestinal tubes offers a higher level of comfort for patients receiving enteral nutrition support. Furthermore, the intestines can absorb nutrients more rapidly through this route, contributing to the improvement of the patients' nutritional status.

Currently, blind insertion, X-ray-guided insertion, endoscopy-guided insertion, and ultrasound-guided insertion are commonly used methods for nasal intestinal tube placement in clinical practice. Among them, blind insertion requires a high level of operator expertise and has a lower success rate of one-time incubation. X-ray guidance exposes patients to radiation and does not allow for real-time observation of the tube's placement. Endoscopy-guided insertion is less comfortable for patients and may affect their treatment compliance. Ultrasound-guided insertion is widely used in clinical practice due to its non-invasive and radiation-free nature, as it does not cause adverse stimulation to patients.[10,11] In ultrasound-guided nasal intestinal tube placement, key anatomical locations for positioning include the gastric antrum, the duodenal bulb, and the horizontal portion of the duodenum. Research by Wu Weihua et al.[12] suggests that the positioning method at the horizontal portion of the duodenum has high sensitivity and specificity and can be considered a preferred examination site. However, patients with severe acute pancreatitis often have symptoms such as gastrointestinal gas accumulation and upper abdominal distention, which can interfere with ultrasound imaging of the nasal intestinal tube, affecting the effectiveness of ultrasound evaluation.[13] Therefore, conducting research to enhance ultrasound localization and tube visualization is crucial. Some studies have indicated that microbubble ultrasound contrast agents can enhance contrast and improve ultrasound visualization of the nasal intestinal tube. However, the high cost of contrast agents limits their clinical application.[14] Another study suggested that injecting gas into the nasal intestinal tube can create a gas reflection interface, which helps enhance echo intensity and improve ultrasound visualization of the tube.[15] However, since patients with severe acute pancreatitis often have gastrointestinal distention, excessive gas injection may not achieve the desired enhancement effect and may worsen the patient's abdominal bloating. In this study, the horizontal portion of the duodenum was used as the key site for ultrasound localization of the nasal intestinal tube. The findings indicated that in the observation group, the nasal intestinal tube visualization rate was higher, the incubation time was shorter, the volume of water injected during the incubation was lower, and the success rate of one-time incubation was higher compared to the control group. This indicates that ultrasound-guided combined with water and air mixed injection can enhance the nasal intestinal tube visualization rate and success rate of one-time incubation while reducing incubation time and the volume of water injected during the incubation. During routine ultrasound examination, the nasal intestinal tube appears similar to the intestinal wall and small abdominal blood vessels, making it challenging to distinguish.[16] However, when a mixture of water and air is injected into the nasal intestinal tube lumen, the significant acoustic impedance difference between the internal gas and the intestinal wall creates a clear beaded gas reflection interface, making it easier to distinguish.[17]

I-FABP and D-lactate are indirect indicators used to assess gastrointestinal mucosal barrier function. For the first time, I-FABP was extracted from the intestine, I-FABP plays a crucial role in intracellular transport and fatty acid absorption, rich in tissue content and high tissue specificity; while D-lactate is a bacterial fermentation product. Generally, its content in the peripheral blood circulation is low. When severe pancreatic cancer occurs, it will damage the patient's digestive system, cause damage to gastrointestinal mucosa and intestinal epithelial cells, induce vasoconstriction, lead to gastrointestinal ischemia, and cause a large number of the above two indicators to be released into the blood.[18,19] The outcomes of this study demonstrated that the observation group had lower levels of I-FABP and D-lactate in comparison to the control group. Conversely, the observation group exhibited higher levels of Hb and RBP. Additionally, the observation group had fewer complications than the control group. These findings suggest that ultrasound-guided combined with water and air mixed injection can regulate the gastrointestinal mucosal barrier function of patients with severe acute pancreatitis, improve their nutritional status, and reduce complications. The goal of early post-pyloric feeding is to promote the recovery of gastrointestinal function in patients with severe acute pancreatitis while reducing pancreatic stimulation and preventing excessive pancreatic secretion, which could exacerbate pancreatic injury.[20] During the placement of a nasal intestinal tube, excessive water injection may stimulate the pancreas, enhance exocrine pancreatic function, and worsen the patient's condition. Excessive air injection, on the other hand, can lead to gastrointestinal gas accumulation, making it difficult to expel and increasing the gastrointestinal burden, which is unfavorable for intestinal nutrient absorption.[21,22] The use of a 5:5 mixture of water and air in ultrasound-guided combined injection can avoid excessive water or air injection into the body, helping to reduce pancreatic stimulation, maintain gastrointestinal mucosal barrier function, and reduce abdominal distension and edema. This facilitates better nutrient absorption by the intestines, thereby improving the patient's nutritional status. However, this study is a single center study with a small sample size included, and the research results may have some bias. In the future, the sample size of the study can be expanded and different proportions of mixed water and gas can be set for further exploration.

In summary, using ultrasound-guided combined with water and air mixed injection to place a nasal intestinal tube in patients with severe acute pancreatitis can shorten the incubation time, reduce the volume of water injected during the incubation, increase the nasal intestinal tube visualization rate, improve the success rate of one-time incubation, enhance the function of the gastrointestinal mucosal barrier, improve nutritional indicators, and reduce the occurrence of complications.

ETHICAL COMPLIANCE

This study was approved by the ethics committee of Guangzhou First People's Hospital. Signed written informed consents were obtained from the patients and/or guardians.

CONFLICT OF INTEREST

The authors have no potential conflicts of interest to report relevant to this article.

AUTHOR CONTRIBUTIONS

YF and JZ designed the study and performed the experiments, QW, WS andZY collected the data, HL, ML and WG analyzed the data, YF and JZ prepared the manuscript. All authors read and approved the final manuscript.

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