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Revisión

Advancements in the application of semi-solidified feeding in enteral nutrition for critically-ill patients – A comprehensive review

Avances en la aplicación de la alimentación semisólida en la nutrición enteral para pacientes críticamente enfermos: una revisión integral

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Keywords:

Enteral nutrition. Semi-solidified. Critically ill patients. Review.

Abstract

Enteral nutrition represents the primary modality of nutritional support for critically ill patients. However, challenges such as gastroesophageal reflux, diarrhea, and abdominal distension often manifest during its administration. Enteral nutrition semi-solidified feeding has emerged as a promising alternative, demonstrating notable efficacy. This study systematically explores the literature on semi-solidified enteral nutrition, discussing its conceptual framework, classifications, relative merits, and drawbacks compared to traditional enteral nutrition. Additionally, it illustrates clinical application and associated complications, offering valuable insights for the implementation of semi-solidified enteral nutrition in critically ill patients.

Palabras clave:

Nutrición enteral. Semisólida. Pacientes críticamente enfermos. Revisión.

Resumen

La nutrición enteral representa la modalidad principal de soporte nutricional para los pacientes críticos. Sin embargo, problemas como el reflujo gastroesofágico, la diarrea y la distensión abdominal surgen a menudo durante su administración. La alimentación semisólida en nutrición enteral ha surgido como alternativa prometedora, demostrando una notable eficacia. Este estudio explora sistemáticamente la literatura sobre la nutrición enteral semisólida, exponiendo su marco conceptual, clasificaciones, méritos relativos y desventajas en comparación con la nutrición enteral tradicional. Además, ilustra la aplicación clínica y las complicaciones asociadas, ofreciendo valiosas perspectivas para la implementación de la nutrición enteral semisólida en pacientes críticamente enfermos.

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INTRODUCTION

Critically ill patients frequently experience issues such as impaired consciousness and swallowing function, acute stress response, hormonal imbalances, and visceral dysfunctions. These factors can contribute to metabolic disorders and malnutrition. At present, a standardized and unified approach for diagnosing malnutrition in critically ill patients has yet to be established. Clinically, the most frequently employed tools for screening and assessing malnutrition include the Nutritional Risk Screening (NRS) 2002, the Malnutrition Universal Screening Tool (MUST), the Mini-Nutritional Assessment-Short Form (MNA-SF), the Subjective Global Assessment (SGA), and the Nutrition Risk in Critical Illness (NUTRIC) score (1-3). These instruments are crucial in clinical practice for facilitating the identification of patients in need of nutritional intervention by healthcare professionals. In a case-control study, SGA, MNA, or nutrition screening tools were conducted before or within 48 hours of ICU admission; results indicated that the prevalence of malnutrition ranged from 38 % to 78 (4,5). Consequently, nutritional support is essential for this patient population. The goals of nutritional support extend beyond weight maintenance to include the preservation of tissue and organ structure and function. Nutritional support is vital for maintaining cellular metabolism, regulating physiological functions, and promoting tissue repair, thereby aiding in the recovery of critically ill patients (6).

Enteral nutrition is the preferred method of nutritional support for critically ill patients, as it helps maintain the structural and functional integrity of the gastrointestinal mucosa while meeting the body's nutritional and energy requirements (7). The benefits of enteral nutrition include the protection of gastrointestinal tract and immune barrier functions, as well as the reduction of complications related to nutrient metabolism and infections (8). However, enteral nutrition can also lead to various intolerances such as gastroesophageal reflux, diarrhea, and abdominal distension (9), with incidence rates ranging from 41.27 % to 73.6 % (10). Reports indicate that 39 % of patients receiving tube-feeding enteral nutrition experience high gastric residuals. Other common complications include constipation (15.7 %) (11), diarrhea (ranging from 2.0 % to 95.0 %) (12). The incidence of diarrhea during enteral nutrition is influenced by various factors, and there is a significant variation in its incidence, including different types of patients and settings, the patient's condition and the specific implementation method of enteral nutrition (11,13). Abdominal distension (12.2 %) (14), vomiting (13.2 %) (11), and nausea (ranging from 10 % to 20 %) (11). Reflux occurs in 0.4 % to 6.0 % of cases, while pneumonia is reported in 12.5 % to 30.0 % of patients referring to enteral nutrition-related pneumonia exclude other types of pneumonia common in the critically ill patient (ventilator-associated pneumonia) (11,12,15). Additionally, 15.2 % of patients discontinue enteral nutritional support due to uncontrollable gastrointestinal complications (16). These complications can impede the successful administration of enteral nutrition, leading to inadequate nutritional support, prolonged hospital stays, and increased mortality (9). Therefore, it is crucial to focus on preventing gastrointestinal complications in patients requiring nutritional management.

To mitigate the potential gastrointestinal complications associated with enteral nutrition, healthcare providers often recommend the use of commercially available thickeners to achieve a nectar- or honey-like consistency (17,18). In critically ill patients taking oral enteral nutrition preparations, thickened liquids can slow the swallowing process, enhancing safety and potentially compensating for delayed pharyngeal swallowing or incomplete airway closure (19). Building on this concept, researchers have suggested the implementation of semi-solidified enteral nutrition (20), which has shown promising outcomes (21). By comparing two groups of severe patients with no statistical difference in acute gastrointestinal injury, it was found that the semi-solidified feeding group achieved a higher percentage of daily prescribed calories, particularly in the first three days. Additionally, total daily caloric intake was higher, and the incidence of feeding intolerance was lower in this group (22). Therefore, semi-solidified feeding shows outstanding advantages in nutritional support for critically ill patients and holds promising prospects. This study reviews the concept, classification, advantages and disadvantages of semi-solidified enteral nutrition compared to traditional enteral nutrition through literature analysis. It further evaluates clinical outcomes, gastrointestinal tolerance and complications to provide reference for the clinical practice of enteral nutrition and semi-solidified feeding in critically ill patients.

THE CONCEPT OF SEMI-SOLIDIFICATION OF ENTERAL NUTRIENTS

Currently, there is no authoritative definition of semi-solidified enteral nutrition. The concept was first introduced by Japanese researchers to prevent complications such as diarrhea, gastroesophageal reflux, and aspiration pneumonia by increasing the viscosity of enteral nutrition solutions. Semi-solid feeding aims to prevent these complications by increasing the viscosity or altering the properties of enteral nutrition formulations (11). Launched in Japan in 2014, semi-solid nutritional preparations are both affordable and versatile. Recent literature reports indicate that these more viscous preparations effectively reduce gastroesophageal reflux in patients undergoing percutaneous endoscopic gastrostomy (11). The current concept of semi-solidified enteral nutrition, based on existing research, involves adding semi-solidifying agents such as pectin, agar, and guar gum to traditional enteral nutrition liquids. This process transforms the liquid into a semi-solidified chyme, either within the human stomach or outside the body, resembling the chyme produced by the stomach's natural grinding action. This approach closely approximates the normal eating state, and semi-solid enteral nutrition has been shown to significantly improve gastrointestinal tolerance by reducing the incidence of complications such as diarrhea, vomiting, and abdominal distension, and maintaining gut barrier function (23,24). This mode of nutritional support has been supported by research in critically ill patients, demonstrating its advantages in enhancing nutritional status and reducing gastrointestinal intolerance.

CLASSIFICATION OF SEMI-SOLIDIFIED NUTRITIONAL PREPARATIONS

Semi-solid nutritional supplements can be divided into two types. The first type is commercially available semi-solid nutrient. There are more than 10 such products on the Japanese market, including semi-solid nutraceuticals first launched in 2014. These semi-solid formulas and food additives increase the viscosity of liquid formulas by 2000-20000 mPa·s (25). The instructions for semi-solid nutritional supplements typically recommend a standard adult dose of 1200-2000 kcal/day, administered directly into the stomach through a gastrostomy tube several times a day. Administration should occur at a rate of 100 g every 2-3 minutes, with a maximum single dose of 600 g. The second type involves adjusting the viscosity of commercially available liquid nutrients by adding thickeners or gelling agents such as agar, gelatin, pectin, carrageenan, starch, guar gum, or xanthan gum (26). These nutrients can be administered directly through the feeding tube, while the thickeners or gelling agents are administered separately, allowing partial coagulation to occur in the stomach.

ADVANTAGES AND DISADVANTAGES OF SEMI-SOLIDIFIED FEEDING

The physiological basis for the application of semi-solidified feeding in enteral nutrition for critically ill patients mainly involves nutrient absorption efficiency, regulation of gastrointestinal function, and reduction of feeding-related complications. Compared with traditional enteral nutrition, advantages and disadvantages of semi-solidified feeding are revealed in table I. Adverse reaction comparison between traditional enteral nutritional support and semi-solidified feeding are revealed in table II.

Table I. Advantages and disadvantages of semi-solidified feeding

Semi-solidified feeding		
Advantages	Reduce feeding complications	Vomiting (11)
		Diarrhea (32)
		Bloating (14)
	Ensure energy supply and improve nutritional indicators (22)	
	Improve feeding difficulties in critically ill infants (44)	
	Protect the immune barrier function of the gastrointestinal tract, reduce the occurrence of infectious diseases (37,53,54)	
	Improve intestinal microecology (40,32)	
Disadvantages	Pharmacokinetic interaction between semi-solidified enteral nutrition and carbamazepine shows it leads to a reduction in plasma concentration of carbamazepine (47)	
	Aspiration is less likely to occur but more severe (48)	

Table II. Adverse reaction comparison between traditional enteral nutritional support and semi-solidified feeding

Incidence	Traditional enteral nutritional support	Semi-solidified feeding
Vomiting	≈ 13.2 % (11)	≈ 9.1 % (24)
Nausea	10 %-20 % (11)	Relatively low
Diarrhea	≈ 30.8 % (31)	≈ 28 % (26)
Bloating	≈ 12.2 % (14)	7.2 % (24)
Constipation	≈ 15.7 % (11)	≈ 11.8 % (11)
Malnutrition incidence	≈ 32.6 % (55)	-
Pharmacokinetic interaction	-	Carbamazepine (47)
Asphyxia	-	Relatively low

REDUCES FEEDING COMPLICATIONS

Reduces the incidence of vomiting

There are many reasons for vomiting in critically ill patients. One reason is that these patients are prone to gastrointestinal dysfunction and reduced gastric motility, and ordinary nutritional solutions are thin liquids. Critically ill patients are more likely to experience gastric reflux when they are supine, resulting in vomiting (27). Meta-analyses show that semi-solidified enteral nutrition can significantly reduce the incidence of reflux (11). This may be because pectin, a plant additive, can combine well with calcium ions without altering the composition of the nutrient solution, forming a semi-solid state similar to chyme after food has been ground in the stomach. This reduces the occurrence of reflux, thereby decreasing the incidence of vomiting, and aligns more closely with the physiological characteristics of human digestion and absorption (22). At the same time, semi-solidified enteral nutrition has a shorter residence time in the proximal stomach, which can promote gastric motility and accelerate gastric emptying, further reducing the occurrence of vomiting. Dupont (28) reported about 14 % reduction in vomiting among patients receiving pectin-enriched, semi-solid enteral nutrition. Similarly, in Kanie's (29) study, seventeen ICU patients who were on PEG feeding participated, liquid or semi-solid nutrients were administered via PEG tubing in a randomized order. The research results found about 25 % decrease in vomiting rates when intermittent feeding with semi-solid nutrients was implemented in ICU patients. These findings underscore the clinical efficacy of semi-solid enteral nutrition in reducing vomiting in critically ill patients.

Reduces the incidence of diarrhea

Diarrhea in critically ill patients can lead to insufficient nutritional intake, secondary water and electrolyte imbalances, skin

and mucosal damage, and an increased risk of infection and death (30). Among patients receiving enteral nutritional support, the incidence of diarrhea ranges from 2 % to 95 % (12). In a prospective, multicenter, observational study, 533 ICU patients receiving enteral nutrition treatment were enrolled. Events were observed continuously for 7 days or until patients were transferred out of the ICU after enteral nutrition. The study found that the incidence of diarrhea in critically ill patients is 30.8 % (31). A clinical trial reported a decrease in diarrhea rates from 40 % to 20 % after introducing semi-solid enteral feeding in ICU patients (32,33). Another study found that patients receiving semi-solid enteral nutrition experienced a 9 % reduction in gastrointestinal complications, particularly diarrhea (26). In a study by Nakamura (34), propensity score matching was performed on age, gender, and organ dysfunction of 693 eligible patients, the results indicated that semi-solidified enteral nutrition significantly reduced the incidence of diarrhea and nosocomial pneumonia in critically ill patients. Kagawa's (35) research found that semi-solidified enteral nutrition management can reduce the risk of diarrhea and mitigate local inflammation under septic conditions, in his study, mice in the experimental group showed significantly down-regulated protein expression of pro-inflammatory cytokines such as small intestinal tumor necrosis factor-α, liver interleukin-1β, and interleukin-6.

The reduction in diarrhea observed in patients receiving semi-solidified enteral nutrition may be attributed to the added pectin. Pectin is a type of water-soluble dietary fiber that has been shown to protect intestinal function and improve intestinal tolerance (36). On the one hand, pectin is decomposed into short-chain fatty acids in the intestine, which provides energy for intestinal epithelial cells and promotes the growth of intestinal mucosa (37). On the other hand, after the colon absorbs short-chain fatty acids, it can strengthen Na^+-H^+ exchange in the intestinal mucosa, promote Na^+ and water absorption, reduce fecal water content, and improve diarrhea symptoms (38).

Reduces the incidence of bloating

The incidence of bloating due to intestinal intolerance can reach 12.2 % (14). Abdominal distension can produce flatulence that compresses the diaphragm and chest cavity of critically ill patients, leading to vomiting, difficulty breathing, and interruption of enteral nutrition. Additionally, increased abdominal pressure can obstruct inferior vena cava return, resulting in lower limb venous thrombosis and damage to abdominal organs (39). Studies have shown that semi-solidified enteral nutrition can accelerate gastric emptying and reduce the occurrence of enteral feeding intolerance, such as abdominal bloating (14). A meta-analysis including 8 randomized controlled trials involving 823 tube feeding patients showed that in patients using semi-solidified enteral nutrition, the incidence of abdominal distension is reduced by approximately 59 %, thereby significantly improving patients' gastrointestinal tolerance and comfort (24). Pectin, once decomposed into short-chain fatty acids in the intestine, lowers intestinal pH and promotes the growth of beneficial probiotics. This process reduces bacterial translocation and the proliferation of pathogenic bacteria (40). Probiotics improve intestinal blood supply and promote peristalsis, thereby reducing bloating (41). However, some studies indicate that while early enteral feeding with pectin can reduce the incidence of vomiting and diarrhea, it may not significantly impact abdominal distension (42). This variability may be due to the different causes of abdominal distension, diverse patient populations, varying disease characteristics, and differences in feeding protocols, including the type and dosage of nutrient solutions used.

ENSURE ENERGY SUPPLY AND IMPROVE NUTRITIONAL INDICATORS

Research conducted by Xi (43) further corroborated the safety and effectiveness of semi-solidified feeding for critically ill patients. Enteral nutrition is a crucial method for providing direct nutrient absorption for critically ill patients. Semi-solidified nutrient solutions can enhance the residence time of nutrients in the intestine and promote nutrient absorption due to their unique physical properties. The moderate viscosity of semi-solidified nutrient solutions facilitates better contact with the intestinal mucosa, thereby improving nutrient penetration and absorption efficiency.

Enteral nutrition intolerance in patients can result in reduced nutrient absorption, prompting doctors to consider temporarily suspending or changing the type of nutrient solutions. Consequently, enteral nutrition intolerance directly impacts patients' nutritional intake, affecting their recovery from illness. On one hand, semi-solidified enteral nutrition can expedite critically ill patients' attainment of required nutritional standards and increase calorie intake to support recovery (37). On the other hand, semi-solidified feeding can safeguard the gastrointestinal tract, reduce the incidence of infectious diseases, ensure adequate energy supply, and enhance nutrition-related indicators (40). In a clinical study, the 60 patients were divided into the two groups (30 patients each), the experimental group (enteral nutrition solution + probiotics + 90 ml of pectin) and the control group (enteral nutrition solution + probiotics). The time required to achieve the nutritional target of each patient were recorded, and the serum pre-albumin (PA) levels were measured in order to assess the patients' nutritional statuses. Research results show semi-solidified feeding improves the intestinal condition of critically ill patients, prolongs nutrient retention in the intestines, achieves target nutrient levels earlier than conventional enteral nutrition feeding, and enhances patients' nutritional status (37). A retrospective cohort study was conducted on 40 patients who underwent postoperative nutritional management through nasogastric tubes, studies have shown that subjects fed semi-solid nutrients experienced a significant increase in 3-day caloric intake compared to the control group, although the length of hospitalization remained unchanged (22), at the same time, semi-solidified feeding effectively decrease the length of hospitalization, reduce

complications, maintain nutritional status, improve quality of life, and ensure energy supply by shortening administration time (22), and they also did not significantly affect blood glucose variability or stress hyperglycemia (11), but further research is needed to clarify its optimal applications and patient groups that would benefit. Moreover, among patients using gastric acid suppressants, the enteral nutrition failure rate did not differ between those receiving semi-solid feeding and those who did not. This finding underscores the efficacy of semi-solid feeding in critically ill patients, irrespective of gastric acid suppressor use, and its ability to reduce the incidence of enteral nutrition failure and diarrhea (34).

In addition, some studies have found that semi-solidified enteral nutritional support can enhance intestinal function by improving intestinal microecology. Neurocritically ill patients often experience heightened catabolism and inadequate nutritional intake due to impaired consciousness, autonomic dysfunction, or malabsorption. With the advent of theories such as ectopic intestinal flora, intestinal mucosal barrier protection, and intestinal immune function, the significance of semi-solidified enteral nutritional support for such critically ill patients has gained increasing attention (11,37). Pectin in semi-solidified enteral nutrition preparations serves as an adhesive and protective carrier for intestinal flora and is indigestible by the human gastrointestinal tract. It stimulates gastrointestinal peristalsis, further protects the intestinal mucosal barrier, reduces intestinal ectopic bacteria, enhances intestinal immune function, improves albumin levels and nutritional status, and accelerates the recovery process of patients (37).

IMPROVE FEEDING DIFFICULTIES IN CRITICALLY ILL INFANTS

A common strategy for managing feeding difficulties in critically ill infants is to control fluid viscosity by incorporating thickeners into formula or expressed breast milk. Semi-solidified feeding is widely employed in Canadian infants to address feeding challenges (44). It has been shown to significantly decrease the decline in oxygen saturation and bradycardia associated with oral feeding in premature infants, thereby aiding in stabilizing their oxygen saturation and heart rate during feeding (45). Despite its widespread use and observed benefits, there is a lack of clinical practice guidelines for the implementation of this strategy, highlighting the need for further research and standardization in this area.

POSSIBLE ADVERSE EFFECTS OF SEMI-SOLID FEEDING

Compared with ordinary enteral nutrition preparations, semi-solidified enteral nutrition support helps reduce the risk of feeding complications, there are few reports or studies on the adverse reactions. However, if used improperly, it can also cause adverse effects and increase the risk of complications.

Pharmacokinetic interaction with drugs

Studies have indicated that most semi-solid feedings do not affect pharmacokinetic efficiency or the bioavailability of drugs (46). However, Nagai (47) conducted animal experiments to investigate the impact of semi-solidified enteral nutrition on the pharmacokinetics of oral carbamazepine in rats. The results revealed a pharmacokinetic interaction between semi-solidified enteral nutrition and carbamazepine, leading to a reduction in plasma concentration of carbamazepine. Therefore, when critically ill patients receive semi-solidified enteral nutrition and require oral carbamazepine, establishing a dosing interval between the two is necessary to avoid pharmacokinetic effects. Currently, there are limited reports on the interaction between semi-solidified enteral nutrition preparations and drugs, and further research is warranted for deeper exploration.

Aspiration risk

Compared with ordinary enteral nutrition preparations, semi-solid nutrients as a whole, have clear advantages of reducing gastroesophageal reflux and subsequent aspiration pneumonia, but Masatoshi's (48) reported a case involving an 82-year-old critically ill patient who experienced tracheal obstruction and pulmonary failure due to inhalation of semi-solidified enteral nutrition. Several factors may have contributed to this outcome: Firstly, the patient's advanced age and compromised digestive function could have rendered them more susceptible to incomplete digestion of the highly viscous semi-solidified enteral nutrients. Additionally, the patient reclined immediately after nutritional feeding, it could have increased the risk of reflux, although reports of reflux complications associated with semi-cured enteral feeding are rare, these risks should not be disregarded. Moreover, there are no standardized guidelines regarding the optimal ratio, viscosity, and infusion rate of semi-solidified enteral nutrition. Factors such as the concentration of calcium ions in the enteral nutrition solution, the quantity of semi-solidifying agents, and the pH of the patient's gastric juice are also not standardized. Therefore, if the viscosity of the semi-solidified enteral nutrition solution is excessively high or if feeding practices are inappropriate, there is a small probability of reflux occurring, and in severe cases, excessive viscosity of semi-solidified enteral nutrition can lead to fatal asphyxia in critically ill patients.

Other risks

For patients receiving semi - solidified enteral nutrition solution via tube feeding, a high viscosity of the semi-solidified enteral nutrition may easily lead to the formation of sediment or blockage in the feeding tube (49). Therefore, during the administration of semi-solid enteral nutrition, the appropriate feeding route should be selected according to the formula of the semi-solid enteral nutrition agent and the patient's own disease condition.

This is essential to avoid tube blockage during the feeding process, which might otherwise affect the nutritional support for critically ill patients. Before and after each feeding, it is necessary to rinse the tube with warm water to ensure its patency. In addition, if the fiber content of the semi-solidified nutritional preparation is insufficient or excessive, constipation or diarrhea are also common symptoms as with traditional enteral nutrition preparations (50,51). Due to the complexity of formulation design, some patients may develop metabolic disorders, especially in the presence of electrolyte imbalance (49,52).

Therefore, medical staff must fully understand the potential risks when using it, follow the principles of individualization and step-by-step, and pay close attention to changes in the patient's condition to ensure the safety and effectiveness of nutritional support.

APPLICATION OF SEMI-SOLIDIFIED FEEDING IN CRITICALLY ILL PATIENTS

Compared with traditional enteral nutrition, semi-solid feeding has many advantages and has gradually attracted attention in clinical applications in critically ill patients. It has been widely used in Japan, but research in other countries is limited.

INITIATION STRATEGY FOR SEMI-SOLID ENTERAL NUTRITION

Before introducing semi-solid enteral nutrition, it is essential to assess whether the patient's digestive function is suitable for such feeding. Initially, feeding should start with a small volume and low viscosity, which can be gradually increased to ensure patient tolerance (56).

At present, semi-solidified enteral nutrition feeding methods are mainly divided into intermittent feeding and continuous feeding. In the study, Toh (57) used semi-solidified enteral nutrition formulated directly by the manufacturer to provide intermittent feeding to critically ill patients through a nasogastric tube. The caloric density is 0.8 kcal/ml. Feeding starts from 300 kcal/d and gradually increases to 900 kcal/d. Kanie (29) drew the pre-prepared semi-solidified enteral nutrition into a 50 ml syringe and injected it directly through the gastrostomy tube for 5 minutes. Shao (33) administered a pectin semi-curing agent and enteral nutrition solution in a ratio of 1:5 to critically ill patients for post-pyloric intermittent feeding. Specifically, the pectin semi-curing agent is fed first, followed by flushing the tube with 10 ml of warm boiled water. Then, the enteral nutrition solution is pumped according to the target average amount within 1 hour. Finally, the tube is flushed and clamped. After 3 hours, the tolerance of the critically ill patient is evaluated. If the tolerance is good, the second feeding is performed, and the above process is repeated. Zang (58) first rapidly injected 90 ml of pectin semi-curing agent through the gastric tube, then flushed the tube with 20 ml of warm water. Subsequently, the enteral nutrition solution was rapidly pumped at a pump speed of 250-400 ml/h. The pumping time is ≤ 1 h. Feeding commences at 7:00 am every day, with one feeding every 5 hours, for a total of four intermittent feedings. In addition, Lu (59) also used semi-solidified enteral nutrition intermittent feeding in their study to reduce the incidence of enteral feeding intolerance in critically ill patients. Intermittent feeding with semi-solidified enteral nutrition is preferable to continuous feeding. This feeding method is more in line with the normal physiological eating state of the human body.

SELECTION OF INITIAL VISCOSITY FOR SEMI-SOLID ENTERAL NUTRITION

The viscosity of semi-solidified enteral nutrition mainly depends on the ratio of calcium ion concentration and semi-solidifying agent concentration in the enteral nutrition solution and is also affected by factors such as preparation time, stirring time and formula energy density (60). In critically ill patients, excessively high viscosity may cause indigestion or gastrointestinal discomfort, while too low viscosity may not sufficiently reduce reflux and aspiration risks. It is recommended to start with a low viscosity and gradually transition to a semi-solid form. Research shows that when the viscosity of semi-solidified enteral nutrition ranges from 2000 to 20 000 mPa·s, it can effectively reduce diarrhea symptoms in critically ill patients during enteral nutrition (21). Some studies have shown that when the viscosity of semi-solidified enteral nutrition ranges from 5000 to 20000 mPa·s, it can prevent the occurrence of pneumonia caused by gastroesophageal reflux in critically ill patients during enteral nutrition (61,62). Currently, the viscosity of semi-solidified enteral nutrition is difficult to measure after entering the complex gastrointestinal environment of critically ill patients, and the optimal viscosity range of semi-solidified enteral nutrition has not yet been unified. Therefore, during the preparation process of semi-solidified enteral nutrition, it is necessary to strictly follow the proportions proven to be effective by existing studies.

FEEDING ROUTE AND INFUSION RATE FOR SEMI-SOLID ENTERAL NUTRITION

At present, the feeding routes of semi-solidified enteral nutrition mainly include nasogastric tube, gastrostomy tube and post-pyloric feeding (60). When feeding semi-solidified enteral nutrition, the appropriate feeding route should be selected based on the formula of the semi-solidified enteral nutrition and the patient's disease condition to prevent tube blockage during the feeding process and affect the nutritional support of critically ill patients. Be sure to flush the pipes with warm boiled water before and after feeding to ensure smooth flow of the pipes. In addition, no relevant research has been conducted on whether semi-solidified enteral nutrition can be fed through the nasointestinal tube of critically ill patients. Researchers can explore this aspect in the

future. When adjusting the feeding speed of semi-solidified enteral nutrition, in addition to the nutritional status and gastric retention of critically ill patients, the acidic conditions in the gastric cavity must also be considered, because semi-solidified enteral nutrition is currently formed in the gastric cavity of critically ill patients. The feeding method of nutritional supplements is the most commonly used in clinical practice, and only under good acidic conditions in the gastric cavity can the semi-solidified agent and enteral nutritional solution form a semi-solidified state (20). There is still a lack of relevant research guidance on the adjustment of feeding speed of semi-solidified enteral nutrition. Therefore, more high-quality research can be conducted to explore it.

DISCUSSION

The emergence of semi-solid enteral nutrition provides a scientific and effective solution to solve the problem of low viscosity, fast flow rate and imbalance of bacterial flora in liquid enteral nutrition. Semi-solid enteral nutrition can effectively help critically ill patients adapt to enteral nutrition faster, reduce the incidence of diarrhea, abdominal distension, and vomiting in patients, help patients achieve nutritional standards, create favorable conditions for treatment, reduce the incidence of postoperative complications, and improve prognosis.

Semi-solid enteral nutrition offers numerous advantages and has increasingly become a part of clinical practice, particularly in Japan, has been widely used. However, the methods of semi-curable enteral feeding are varied, and there is a lack of relevant guidelines or scientific guidance from expert consensus. More attention should be paid to the feeding path, speed, viscosity, pharmacokinetic interaction and co-occurrence of the semi-curable enteral nutrition in critically ill patients. In the future, researchers can develop guidelines or expert consensus on semi-curable enteral feeding methods and nursing, so as to guide the development of semi-curable enteral feeding in clinical practice.

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