Original Article

Risk of regurgitation and aspiration in patients infused with different volumes of enteral nutrition

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Background: Patients with stroke suffer from nutrition impairments and often rely on enteral nutrition (EN), which is associated with respiratory complications such as regurgitation and aspiration. **Objective:** To evaluate the incidence of regurgitation and aspiration in patients with severe stroke infused with different volumes of EN. **Methods:** A randomized controlled trial was conducted on 210 patients with severe stroke undergoing EN therapy. Patients were randomly assigned into two groups. Subjects in the treatment group received EN with an initial rate defined according to the total volume and the infusion rate was adjusted based on gastric residual volume (GRV) assessed every 4 hours. Subjects of the control group received EN without monitoring the GRV and reached the target infusion volume within 72 hours. The incidence of reflux and aspiration was recorded. **Results:** The incidences of regurgitation and aspiration were significantly lower in treatment group (6.3% and 7.9%, respectively) than control group (18.8% and 17.5%, respectively). In the treatment group, 1 patient developed regurgitation while 2 developed aspiration when EN was 500 mL. When EN increased to 1000 mL, 2 patients developed regurgitation and 2 developed aspiration, and 5 patients developed regurgitation and 6 had aspiration when EN was 1500 mL. There was no significant difference in the risk of reflux and aspiration when total volume of EN increased from 500 to 1500 mL. **Conclusions:** During EN therapy for patients with stroke, using feeding pump with a continuous infusion for 20 hours and adjusting infusion rate based on GRV could reduce the incidence of respiratory complications.

Key Words: stroke, enteral nutrition, gastroesophageal reflux, aspiration, gastric residual volume

INTRODUCTION

Enteral nutrition (EN) support is the process of providing essential nutrients via an intestinal route to a patient unable to feed themselves. Usually, EN is carried out via an orogastric or a nasogastric tube into the stomach.[1,2] The daily amount of EN is tailored according to the needs of each patient, but a caloric goal of 18-25 kcal/kg·d is universal.[1] Two strategies are used to initiate EN: gradually increasing the infusion rate until the target is achieved, or initiating the infusion just at the target rate,[1] although there is a controversy regarding which approach is better.[3-5] The Early vs Delayed Enteral Nutrition (EDEN) trial suggested that using an initial low-volume EN was associated with fewer adverse events such as diarrhea, vomiting and gastric residuals.[6]

EN is associated with an increased risk of aspiration which may increase the risk of nosocomial pneumonia.[1,7-9] Dysphagia is a common clinical manifestation of stroke, especially for patients with severe stroke who are usually unable to feed themselves; EN is therefore indicated for those patients.[10] A study reported an incidence of aspiration of 15.5% in stroke patients undergoing EN via a nasogastric tube.[11] A multicenter study showed that the rate of nosocomial pneumonia was 21% in critically ill patients with nasogastric nutrition, and early nasojejunal nutrition could not reduce the frequency of pneumonia.[12] In stroke patients suffering from regurgitation, the prevalence of nosocomial pneumonia was reported as high as 18%, with a median survival of 10 months.[8] So far, none of these studies assessed the influence of the EN approach on the risk of regurgitation.

Many causes can lead to aspiration and according to some research studies high gastric residual volume (HGRV) is an important risk factor for aspiration of gastric content.[13,14] Therefore, this study enrolled patients with severe stroke who were planned to receive EN therapy. Patients were randomly assigned into two groups. The experimental group received EN with an initial rate defined according to the total volume and the infusion rate was adjusted based on gastric residual volume (GRV) assessed every 4 hours. The control group received EN without monitoring the GRV and reached the target infusion volume within 72 hours. We aimed to compare the incidence of regurgitation and aspiration between the two

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groups.

MATERIALS AND METHODS

Participants

This prospective study enrolled 210 stroke patients, who were hospitalized for more than 96 hours in the Department of Neurology of the First Affiliated Hospital of Sun Yat-sen University from January 2010 to December 2012. Patients were diagnosed with cerebral infarction/hemorrhage by head computed tomography (CT) or magnetic resonance imaging (MRI) scans.[10,11] Inclusion criteria were: 1) definite indication for EN; 2) age ≥18 years old; and 3) planned ICU length of stay >5 days. Exclusion criteria were: 1) immuno-compromised; 2) hepatic failure; or 3) gastrointestinal issues postoperatively. EN was suspended once a patient suffered from gastrointestinal bleeding, and the patient was excluded. We assumed that the incidence of regurgitation and aspiration in control group would be higher than experimental group. Therefore, patients were recruited into the treatment group (n=126) and control group (n=84) with the ratio of 3:2. The study was approved by the local Ethical Committee of the First Affiliated Hospital of Sun Yat-sen University ([2010]79), and all patients provided a written informed consent.

EN therapy

An indwelling nasogastric tube (#12, polyurethane, CH/FR12, 120 cm, Fresenius Kabi, Idstein, Germany) was prepared to a length of about 55-65 cm (nose-ear-xiphoid distance adding 10 cm). Bedside x-ray was performed within 12 hours to confirm the tube position.

All patients were admitted to the Intensive Care Unit (ICU) and received mechanical ventilation. The infusion of EN started when the hemodynamics were stabilized within 24 hours after ventilation. The nutritional formula was composed of Enteral Nutritional Emulsion (TP), Enteral Nutritional Emulsion (TPF-D), Enteral Nutritional Emulsion (TP-HE), and Enteral Nutritional Suspension (SP). The formula was determined by doctors, based on body mass index, and nutritional targets. The Harris-Benedict equation was used to estimate energy requirements.[15]

Among the patients in the treatment group, the infusion was performed by a feeding pump at a constant rate for 20 hours overnight (from 7:00 am to 3:00 am next morning). The infusion rate was determined based on the total volume of EN. It was initially set to 20 mL/h, and was gradually increased to the target, but peaked at less than 100 mL/h. The total volume of EN was 500-1500 mL. The initial infusion volume was 500 mL EN (at 20-30 mL/h) during the first 24 hours period, and it was increased to 1000 mL (50-60 mL/h) in the second or third 24 hours periods. After 72 hours, if the patient could adapt to EN feeding without any symptoms of bloating, severe diarrhea, or vomiting, and if the gastric residual volume was no greater than 200 mL every four hours,[16] the infusion volume was increased to 1500 mL (80-90 mL/h). GRV was measured on all nasogastric feeding tubes and recorded every 4 hours. The GRV was assessed for total volume, color, and property at 7 am, 11 am, 3 pm, 7 pm, 11 pm, and 3 am next day. The EN infusion rate was adjusted based on the gastric residual volume. The original rate of infusion was maintained if the residue was ≤200 mL. Rate was increased if the residue was ≤100 mL. The rate was lowered and motility agents were added if the residue was ≥200 mL.[16]

The patients in the control group also used the same formula to calculate the energy requirements, but reach the target infusion volume within 72 hours without monitoring the GRV. The volume of EN was increased gradually every day according to energy requirements as follows: Day 1: 33% of the target volume, Day 2: 66% of the target volume, and Day 3: 100% of the target volume.[17]

Patients' care

All nurses in the ICU received training and knowledge about assessment of therapy in a systematic and comprehensive course. They were required to strictly enforce the processes of EN care developed by our department. The nurses were required to place patients at the proper posture. All the patients lay in supine position with the head in the neutral position and upward by 30-45°. In patients with acute cerebral hemorrhage, position of their heads was elevated by 30°.

The nurses had to care for the feeding tube. Nasogastric tubes were fixed using an elastic tape,[1] clearly labeled with tube name, catheter depth, and date. The connector between the nasogastric tube and the nutrient tube was wrapped with a sterile towel. After changing the body position, the patients were patted on the back for suction sputum. The infusion was suspended for 15-30 minutes before and after examination. The length and location of the nasogastric tube were checked to see if it was coiled in the mouth.

The nurses cleaned the tube using the pulse rinse method every 4 hours with 30 mL warm water. The drugs were crushed, dissolved in warm water, and fed to patients separately. Tube rinse was performed when taking drugs and changing infusion bottles before and after suspension of infusion. After finishing feeding, the tube was washed with 30 mL warm water by pulse pressure sealed tube every day. The wall of the tube was gently rubbed with fingers to keep the tube clear.

Strict disinfection and isolation were performed in the ICU. The ward underwent regular alternating ventilation and air disinfection. Room temperature was kept at 26°C and the humidity at 50%-60%. If patients had diarrhea, a heating device was used with the temperature set to 38-40°C and its position was changed every 2 hours.

Airway humidification in patients with mechanical ventilation was conducted by applying strict aseptic methods. Air sac pressure was detected in patients with subglottic tracheal intubation or tracheostomy tube. Before suctioning, the retention below the glottis and above the air sac was rinsed. Oral care was emphasized.

Bladder pressure was measured twice a day. Abdominal girth was measured twice a day or every 8 hours.

Criteria of regurgitation and aspiration

Regurgitation was assumed if the nutrient solution appeared in the mouth during or after EN infusion.[18] Aspiration was considered if sudden cough and difficult breath-

ing were observed, and if any nutrient solution was present in bronchial secretions.[18]

Statistical analysis

Data were analyzed with SPSS 13.0 (SPSS Inc., Chicago, IL, USA). Data are presented as frequency and proportion. Chi-square tests were used for intergroup comparisons. *p*-values <0.05 were considered statistically significant.

RESULTS

Patients' characteristics

Table 1 presents the patients' characteristics. There were 71 males and 55 females in the treatment group, aged 46-87 years, with an average age of 68.1±17.5 years. Among them, 84 suffered from cerebral infarction, and 42 from cerebral hemorrhage. In addition, 92 patients were under mechanical ventilation, and 34 under non-mechanical ventilation. Eight patients underwent surgery, and 118 were without surgical treatment. Based on Acute Physiology and Chronic Health Evaluation (APACHE II), patients ranged from 15 to 27 points, with an average of 19.1±3.4 points. However, based on the Glasgow Coma Score (GCS), they had a score ranging from 3 to 12, with an average of 9.2. There were 4 patients in the control group who did not continue EN for more than 72 hours, and finally 80 patients in this group reached this goal and were recruited for the study. Of these 80 patients, two had gastrointestinal bleeding and two had extubation before the end of the 72 hours. There were 44 males and 36 females in the control group, aged 31-89 years, with an average age of 61.3±14.3 years. Among them, 44 suffered from cerebral infarction, and 36 from cerebral hemorrhage. There was no significant difference between the two groups in ages, APACHE II and GCS scores. There was also no significant between-group difference in the percentage of stroke type (p=0.250), mechanical ventilation (p=0.160) and surgery (p=0.749). Among the patients receiving mechanical ventilation, there was a significant between-group difference in the percentage of stroke type (p=0.411) (Table 1).

Regurgitation and aspiration

During EN therapy, regurgitation and aspiration occurred in 8 and 10 cases, respectively, which accounts for 6.3% and 7.9% of all patients (126 cases) in the treatment group. EN had to been suspended in 4 cases for regurgitation and aspiration and parenteral nutrition was given instead. When EN was 500 mL, 1 patient developed regurgitation while 2 developed aspiration. None of them quit the program. When EN was increased to 1000 mL, 2 patients developed regurgitation and 2 developed aspiration. Only 1 patient quit at this stage. When EN was 1500 mL, 5 patients came up with regurgitation and 6 had aspiration. EN was suspended in 3 patients at this stage. There was no significant difference in the incidence of reflux (p=0.194), aspiration (p=0.212) and suspension of EN (p=0.113) when EN volume varied between 500 mL and 1500 mL. The difference in total volumes of EN did not significantly affect the occurrence of regurgitation and aspiration (Table 2). Meanwhile, regurgitation and aspiration occurred in 15 (18.8%) and 14 (17.5%) cases, respectively, of patients in the control group (80 cases). EN had to been suspended in 6 cases for severe regurgitation and aspiration. There was a significantly higher incidence of regurgitation and aspiration in the control group than that in the treatment group (p=0.006 and 0.037, respectively) (Table 3).

Table 1. Patients' characteristics

Items	Treatment group	Control group
n	126	80
Gender, n (%)		
Male	71 (56.3)	44 (55.0)
Female	55 (43.7)	36 (45.0)
Stroke type, n (%)		
Cerebral infarction	84 (66.7)	47 (58.8)
Cerebral hemorrhage	42 (33.3)	33 (41.3)
APACHE II score, mean±SD	19.1±3.4	18.7±4.1
GCS score, mean±SD	9.2±1.4	8.18±1.6
Post-surgery, n (%)	8 (6.3)	6 (7.5)
Mechanical ventilation, n (%)	92 (73.0)	51 (63.8)
Cerebral infarction	57 (45.2)	28 (35.0)
Cerebral hemorrhage	35 (27.8)	23 (28.8)

SD: standard deviation; APACHE: Acute Physiology and Chronic Health Evaluation; GCS: Glasgow coma score.

Table 2. Patients with regurgitation and aspiration in the treatment group

Infusion volume	n	Regurgitation (cases)	Aspiration (cases)	Suspension of EN (cases)
500 mL	126	1	2	0
1000 mL	126	2	2	1
1500 mL	125	5	6	3
χ^2		3.28	3.10	4.36
p-value		0.194	0.212	0.113

EN: enteral nutrition.

Table 3. Comparison of regurgitation and aspiration between the two groups

Group	n	Regurgitation (cases)	Aspiration (cases)
Treatment group	126	8	10
Control group	80	15	14
χ^2		7.59	4.35
p-value		0.006	0.037

DISCUSSION

It is still controversial about the best way to implement EN in patients with stroke. The aim of the present study was to evaluate the risk of regurgitation and aspiration in patients with severe stroke infused with different volumes of EN. When increasing the EN volume from 500 to 1500 mL, eight patients (6.3%) suffered from reflux and 10 patients (7.9%) suffered from aspiration during EN therapy. There was no significant difference in the risk of reflux and aspiration when the total volume of EN increased from 500 to 1500 mL. This indicates that with careful GRV monitoring, patients with severe stroke could receive a larger volume of EN without increasing risks of aspiration.

It has been reported that regurgitation and aspiratory pneumonia can be prevented by continuous feeding pump, adjusting the infusion rate, progressive increasing of feeding rate and volume.[1,19] We observed that there was no significant difference in the incidence of reflux (p=0.194), aspiration (p=0.212) and suspension (p=0.113) among different groups when the EN volume was varied from 500 mL to 1500 mL. However, there was a significantly higher risk of regurgitation and aspiration in the control group in which patients received the target infusion volume within 72 hours. Therefore, the infusion rate of EN should be initiated from a lower point and go through a gradual increase in volume.

According to the ESPEN (European Society of Parenteral Enteral Nutrition) guidelines, normal glucose tolerance (NGT) feeding is the first choice for patients who need short-term (<4 weeks) EN (A level recommendation).[20] Since nasogastric tubes are easy to place, indwelling nasogastric tubes with small diameter were used in the present study. The length of insertion was defined according to the anatomical length plus 10 cm in order to ensure the end of the tube reached the pylorus and the opening entered the stomach, reducing the occurrence of regurgitation and aspiration caused by gastric retention. In addition, beds should be raised 30-45^o to empty the stomach by gravity and to reduce the reflux of gastric contents. The infusion was suspended for 15-30 min during the change of position, suctioning, before and after physical examination in order to prevent gastric contents from refluxing resulting from external stimulation.

A lot of factors lead to regurgitation and aspiration in patient critically ill such as the state of consciousness, APACHE II score, mechanical ventilation, nasogastric tube position, posture, some care operations, GRV, volume and methods of infusion.[1,4] Among these factors, mechanical ventilation increases intrathoracic pressure, which indirectly elevates the intra-abdominal pressure, and this can result in under-inflation or leakage of air sac and can increase the risk of regurgitation and aspiration.[21-23] In addition, the indwelling endotracheal intubation in combination with tracheostomy tube and nasogastric tube can lower esophageal sphincter pressure.[21] Besides, most critically ill patients suffer from stress-dependent hyperglycemia. High blood glucose can reduce gastric antrum power, causing uncoordinated contraction of the duodenum, and delay gastric emptying.[24,25] Severe gastric stasis could lead to a high incidence of aspiration.[1] The volume of residual gastric contents is closely related to the incidence of regurgitation and aspiration. GRV monitoring is a simple and feasible method to evaluate EN feeding intolerance.[26,27] In the present study, GRV was assessed every 4 hours during EN infusion. It was easy to perform but provided a good approach to evaluate the intolerance to EN feeding. Based on the residual gastric volume, timely interventions could be given to minimize the risk of regurgitation and aspiration.

In the current study, most subjects were unconscious and relied on mechanical ventilation. Regurgitation and aspiration in these patients are often due to decreased swallowing and cough reflexes or was easily induced by daily care operations such as suctioning.[1] The rate of nosocomial pneumonia was reported as high as 18%-21% in previous studies.[8,12] However, the incidence of regurgitation and aspiration was much lower in our study. This might be attributed to the comprehensive education program provided to nurses in our ICU. Additionally, attention was also paid to individualized EN care. It is very important for doctors and nurses in ICU to complement each other well. Once a symptom was noticed, nurses could cooperate with doctors to solve the problems, which contributed considerably to a decreased incidence of regurgitation and aspiration.

Therefore, during EN therapy in patients with severe stroke, it is suggested to apply the detailed safety protocol for EN strictly, to use feeding pumps to accomplish EN for consecutive 20 hours at a constant rate, to define the initial rate based on the total volume, to adjust the infusion rate based on GRV, and to emphasize individual EN care. Using this protocol, regurgitation and aspiration should not increase when enough EN is given.

Conclusion

The risk of reflux and aspiration was not increased when EN infusion volume was increased from 500 to 1500 mL with carefully monitoring of the GRV. During EN therapy for patients with severe stroke, the feeding pump should be used for a continuous infusion for 20 hour and an initial rate based on the total volume of EN. This information should be included in the professional education for nurses and included in the individualized EN care plans in ICU.

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AUTHOR DISCLOSURES

None of the authors have any conflicts of interest associated

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Original Article

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肠内营养不同输注总量出现反流和误吸的风险

背景：脑卒中患者容易伴发营养不良，通常依靠肠内营养（EN）来维持。但肠内营养也存在反流和误吸等呼吸系统方面的并发症。**目的**：探讨重症脑卒中患者在不同 EN 输注总量之间反流及误吸风险的差异。**方法**：选择重症脑卒中患者 210 例进行随机对照研究，患者随机分为 2 组：治疗组患者初始速度根据 EN 总量调节，输注过程中通过每 4 小时测定胃残留量（GRV）的情况进行调速。对照组患者不监测 GRV，在 72 小时内缓慢增速至 EN 目标量。比较两组患者反流和误吸的风险。**结果**：治疗组患者反流和误吸的发生率分别为 6.3% 和 7.9%显著低于对照组的 18.8% 和 17.5%。在治疗组中，500 mL 输注时有 1 例患者发生反流和 2 例患者发生误吸；当输注量增至 1000 mL 时，2 例患者发生反流，2 例患者发生误吸；1500 mL 输注时，5 例患者发生反流，6 例患者发生误吸。EN 输注总量从 500 mL 增至 1500 mL 时，并未显著增加反流和误吸的风险。**结论**：脑卒中患者 EN 治疗过程中，采用以营养泵持续 20 小时匀速输注，初始速度按总量调节，输注过程中通过监测 GRV 调整速度可显著减少呼吸系统的并发症。

关键词：脑卒中、肠内营养、胃食管反流、误吸、胃残留量