



Risk factors of aspiration occurrence with different feeding patterns in elderly intensive care unit patients: a cross-sectional study

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Background: Elderly intensive care unit (ICU) patients represent a high-risk group of aspiration. Different feeding patterns will lead to different incidences of aspiration. However, there are few studies on the risk factors of aspiration in elderly ICU patients under different feeding patterns. The aim of this study was to analyze the effects of different eating styles on the occurrence of overt and silent aspiration in elderly ICU patients and to compare the independent risk factors, in order to provide a basis for targeted aspiration prevention.

Methods: We retrospectively analyzed the incidence of aspiration in elderly patients admitted to the ICU from April 2019 to April 2022, a total of 348 cases. The patients were divided into the oral feeding group, gastric tube feeding group, and post-pyloric feeding group according to their feeding method. Multi-factor logistic regression was used to analyze the independent risk factors for overt and silent aspiration caused by the different eating patterns of patients.

Results: Among the 348 elderly ICU patients included, the overall incidence of aspiration was 72%, with a 22% rate of overt aspiration and a 49% rate of silent aspiration. The overt aspiration rates were 16%, 30%, and 21% in the oral, the gastric tube and the post-pyloric feeding group, respectively; while the silent aspiration rates were 52%, 55%, and 40% in the three groups, respectively. Multiple logistic regression analysis showed that the independent risk factors for both overt and silent aspiration were history of aspiration [odds ratio (OR) =0.075, P=0.004; OR =0.205, P=0.042] and gastrointestinal tumor (OR =0.100, P=0.028; OR =0.063, P=0.003) in the oral feeding group. In the gastric tube feeding group, the independent risk factor for both overt and silent aspiration was the history of aspiration (OR =4.038, P=0.040; OR =4.658, P=0.012). In the post-pyloric feeding group, the independent risk factors for both overt and silent aspiration were mechanical ventilation (OR =0.211, P=0.019; OR =0.336, P=0.037) and intra-abdominal hypertension (OR =0.225, P=0.020; OR =0.329, P=0.032).

Conclusions: There were significant differences in the influencing factors and characteristics of aspiration among the elderly patients in the ICU with different feeding patterns. Personalized precautions should be implemented early, so as to reduce the possibility of aspiration.

Keywords: Aspiration; feeding pattern; intensive care unit (ICU); elderly; risk factors

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Introduction

Aspiration is the process of foreign bodies entering the respiratory tract via the glottis during feeding or non-feeding, and these foreign bodies include secretions, blood, bacteria, food, stomach contents, and so on (1). Aspiration often leads to morbidity and mortality through the direct effects of particulate matter, acid-related injuries, and aspiration pneumonia (2). According to the symptoms, it can be divided into overt aspiration and silent aspiration (3). Overt aspiration refers to the symptoms of irritating choking cough, shortness of breath, cyanosis, and asphyxia immediately after aspiration, whereas silent aspiration refers to an absence of any symptoms or symptoms including only mental depression, apathy, and unresponsiveness; it can lead to chronic cough, chronic bronchitis, interstitial fibrosis, and other diseases in the long term. The incidence of overt aspiration is 8.80–22.45% (4), and the incidence of silent aspiration is as high as 88.00% in intensive care unit (ICU) patients (5). Due to degenerative physiological changes and diseases, the rate of aspiration in elderly people is as high as 57.9%, which is a high-risk group for aspiration. Aspiration can seriously endanger the health of the elderly, and it is the main causative factor of lung infections in the elderly, which can lead to respiratory failure and even death in serious cases.

On account of the severity and specificity of their conditions, elderly patients in the ICU mainly receive

nutrition through oral feeding and tube feeding (6). Some international guidelines that suggest early enteral nutrition as the standard treatment for critically ill patients (7,8). However, the resulting gastric contents reflux is one of the main reasons for aspiration risk in critically ill patients. It has a high incidence of occult aspiration, but because the occurrence of silent aspiration is not perceptible, it is often ignored by clinical staff. Since gastric contents contain gastric acid and pepsin, aspiration can induce a serious inflammatory response and directly damage the airway and alveolar-capillary membrane, which leads to protein-rich intravascular fluid leakage into the alveoli and degrades alveolar surface-active substances, eventually leading to alveolar atrophy and pulmonary atelectasis (9). In addition, gastric contents entering the airway contain large amounts of food residue, and tiny particles can cause extensive small airway obstruction, which can lead to aspiration pneumonia (10). Aspiration pneumonia accounts for approximately 80% of hospitalized elderly patients with pneumonia (11). Previous studies have found that the 5-year mortality rate of patients with respiratory failure due to aspiration pneumonia was 18.7%, which is higher than that of other types of pneumonia (12,13). It is expected to make an increasing contribution to mortality and morbidity among the elderly population in the coming decades (14). Therefore, it is important to understand the characteristics and influencing factors of the occurrence of aspiration in elderly patients with different feeding patterns, in order to enable the implementation of targeted aspiration prevention.

In recent years, several studies in China and internationally (15–19) have shown that the occurrence of aspiration is influenced by a combination of risk factors, which can be categorized as patient-specific factors and treatment-related factors, among which patient-specific factors include age, intra-abdominal hypertension (IAH), gastric retention, swallowing disorder, nausea and vomiting, primary disease, and related symptoms; treatment-related factors include mechanical ventilation, enteral nutrition route, and so on. However, the magnitude of the independent and synergistic risk for aspiration especially for the patients in ICU is not clear and the degree of association with overt aspiration and silent aspiration is less explored. Although many studies (20,21) have been conducted by Chinese and international researchers on the occurrence, assessment, and prevention of aspiration, its incidence remains high. The occurrence of aspiration pneumonia will incur a significantly longer hospital stay,

Highlight box

Key findings

- The characteristics of aspiration occurrence in elderly ICU patients with different feeding patterns are significantly different. We should take early and individualized preventive measures according to the patient's characteristics and eating patterns and should supplement them with targeted nursing interventions to reduce the possibility of aspiration, thus improving the patient's prognosis and enhancing the quality of life.

What is known and what is new?

- Different feeding practices can affect the incidence of overt and silent aspiration.
- Different clinical features have a significant impact on overt versus silent aspiration.

What is the implication, and what should change now?

- In the feeding of elderly patients in the ICU, targeted nursing interventions should be adopted according to the different clinical characteristics of the patients. High priority should be given to high-risk groups and regular checkups to identify the possibility of absorption early, thus improving the quality of patient survival.

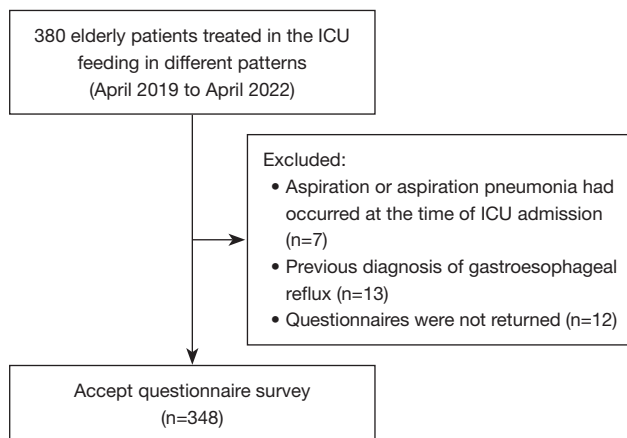


Figure 1 Study flowchart. Elderly patients in the ICU. ICU, intensive care unit.

affect the rehabilitation outcome, increase the mental and economic burden, and have a great impact on the long-term prognosis and quality of life of patients. In addition, some studies (22,23) have reported that overt aspiration accounts for only 10% of aspiration pneumonia, whereas silent aspiration accounts for more than 70%. This suggests that compared with overt aspiration, silent aspiration is not only insidious and difficult to diagnose, but also may be more closely associated with poor prognosis of patients. Based on previous findings and our clinical experience, we speculate that age, dysphagia, aspiration history, and gastrointestinal tumors may be risk factors for aspiration in ICU patients. However, it is not clear whether there are significant differences in the characteristics and influencing factors of overt and silent aspiration in ICU elderly patients with different feeding patterns (22). Therefore, we need investigate the incidence of overt and invisible aspiration in ICU patients and to further clarify their interrelationships as well as the degree of influence on aspiration, so as to identify the risk factors early, implement targeted preventive measures to reduce aspiration complications, and improve the prognosis of patients. We present this article in accordance with the STROBE reporting checklist (available at <https://jtd.amegroups.com/article/view/10.21037/jtd-23-430/rc>).

Methods

Research participants

A total of 348 elderly patients treated in the ICU ward of

Hai'an People's Hospital from April 2019 to April 2022 were included in this study.

The inclusion criteria were as follows: (I) patients were ≥ 65 years of age, regardless of gender; (II) feeding by mouth or tube feeding enteral nutrition; (III) length of hospitalization ≥ 1 week.

The exclusion criteria were as follows: (I) aspiration or aspiration pneumonia had occurred at the time of ICU admission; (II) previous diagnosis of gastroesophageal reflux (*Figure 1*).

The patients were divided into the oral feeding group, gastric tube feeding group, and post-pyloric feeding group according to their feeding method. Finally, according to the inclusion and exclusion criteria, 348 elderly patients treated in the ICU ward were included in this study.

In this study, the incidence of overt aspiration was used as the main outcome index. According to the previous study of the research group, the incidence of overt aspiration in ICU patients was about 20%. The general rule of logistic regression requires a ratio of item number to sample size of 1:5–1:10 and our research factors are about 10. Therefore, the sample size of the study population planned for this study was 380 cases. A total of 12 cases were lost during the research process and 20 cases were excluded. The final count was 348 cases.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Hai'an People's Hospital (No. KYLC2022036). Informed consent was provided by all patients.

General information questionnaire

The general information questionnaire included demographic data (such as gender, age, body mass index (BMI), history of smoking, history of alcohol consumption) and clinical data (such as whether they were taking gastrointestinal motility drugs, whether they were chronically bedridden for ≥ 1 month, and hypertension status).

Investigation of aspiration and its risk factors

Clinical characteristics of the occurrence of overt versus silent aspiration included age, occurrence of impaired consciousness, occurrence of dysphagia, history of aspiration, presence of gastric retention, presence of IAH, occurrence of vomiting, ability to cough spontaneously, presence of gastrointestinal tumors, and whether mechanical

ventilation was required.

The criteria of overt aspiration

As for the patients who eat orally, the patient had no choking cough or cough before eating, and any of the following symptoms during or after eating were judged as overt aspiration: (I) irritating cough; (II) abnormal pronunciation; (III) cyanosis, dyspnea, asthma, and sudden drop in oxygen saturation.

As for the patients with enteral nutrition, no choking cough or cough before nasal feeding, any of the following conditions during or after nasal feeding can be judged as dominant aspiration: (I) vomiting and sudden drop in blood oxygen saturation; (II) shortness of breath, dyspnea, obvious wet rales in the lungs, sputum sound in the throat, man-machine confrontation; (III) gastric contents were aspirated from the airway or found in sputum culture; (IV) there were no clinical symptoms of inhalation, but it was diagnosed as aspiration pneumonia (24,25).

The criteria of silent aspiration

In this study, the content of pepsin in airway secretions was determined by enzyme-linked immunosorbent assay (ELISA) as a basis for determining occult aspiration (26). Secretion specimens were collected respectively from 12 to 72 hours after fasting and feeding states of patients. For patients without an artificial airway, if the content of pepsin in 2 saliva specimens was >3.6 ng/mL, the patient was considered to have an occult aspiration (27), whereas for patients with an artificial airway, if the content of pepsin in 2 airway secretion specimens was >25.0 ng/mL, the patient was considered to have an occult aspiration (28).

Statistical analysis

The software SPSS 26.0 (IBM Corp., Armonk, NY, USA) was used for statistical processing. Normality test was conducted on continuous variables, and the level of $\alpha=0.10$ was considered that the population obeyed normal distribution. The skewness continuous variable data is converted from skewness data to normal data for further analysis and calculation. The measurement data were expressed as mean \pm standard deviation (SD) with independent samples *t*-test; the count data were expressed as number of cases and percentage with chi-square test, and the two-group chi-square test was used for two-

group comparison. Multiple logistic regression analysis was performed on the independent variables. A two-sided *P* value <0.05 was considered a statistically significant difference.

Results

Baseline data

The baseline characteristics of the patients are shown in *Table 1*. A total of 348 elderly patients in the ICU were included in this study, with a mean age of 68.8 ± 3.2 years in the non-aspiration group, including 56 male patients and 43 female patients; and a mean age of 70.2 ± 3.4 years in the aspiration group, including 132 male patients and 117 female patients. A total of 50 patients in the non-aspiration group took gastrointestinal motility drugs and 49 patients did not take them; in the aspiration group, a total of 82 patients took gastrointestinal motility drugs and 167 patients did not take them. A total of 37 patients in the non-aspiration group had a history of prolonged bed rest and 62 patients did not; a total of 128 patients in the aspiration group had a history of prolonged bed rest and 121 patients did not. There were significant differences ($P<0.05$) between the aspiration group and the non-aspiration group in terms of age, taking gastrointestinal motility drugs or not, and prolonged bed rest history or not (*Table 1*).

Status analysis of aspiration in ICU elderly patients with different feeding patterns

Among 348 elderly patients in ICU, aspiration occurred in 249, and the incidence of aspiration was 72%. Among them, there were 78 people of overt aspiration with an incidence of 22% and 171 cases of silent aspiration with an incidence of 49%. The differences in the incidence of overt and silent aspiration between the oral feeding group, the gastric tube feeding group, and the post-pyloric feeding group were statistically significant ($P<0.05$) (*Table 2*; *Figure 2*).

Comparison of overt aspiration characteristics in ICU elderly patients with different feeding patterns

Among patients with overt aspiration, the differences among the 3 groups were statistically significant ($P<0.05$) in terms of swallowing disorder, gastric retention, IAH, spontaneous cough, and mechanical ventilation (*Table 3*), whereas the results of the two-way comparison showed that

Table 1 Comparison of clinical data between aspiration group and non-aspiration group

Projects	Non-aspiration group	Aspiration group	$\chi^2/Z/t$ value	P value
Age (years)	68.8±3.2	70.2±3.4	3.422	0.001
Gender			0.360	0.548
Male	56 [57]	132 [53]		
Female	43 [43]	117 [47]		
BMI (kg/m ²)	21.07±3.39	20.72±2.82	0.971	0.332
Smoking history			1.370	0.242
Yes	51 [52]	111 [45]		
No	48 [48]	138 [55]		
Drinking history			0.588	0.443
Yes	44 [44]	122 [49]		
No	55 [56]	127 [51]		
Hypertension or not			0.323	0.570
Yes	42 [42]	114 [46]		
No	57 [58]	135 [54]		
Taking gastrointestinal motility drugs			9.292	0.002
Yes	50 [51]	82 [33]		
No	49 [49]	167 [67]		
Long-term bed rest time			5.594	0.018
Yes	37 [37]	128 [51]		
No	62 [63]	121 [49]		

Data are presented as mean ± SD or n [%]. BMI, body mass index; SD, standard deviation.

Table 2 Comparison of types of aspiration in patients with different feeding patterns

Group	Number of cases	Overt aspiration, n [%]		Silent aspiration, n [%]	
		Occurrence	Did not occur	Occurrence	Did not occur
Oral feeding group	103	16 [16]	87 [84]	54 [52]	49 [48]
Gastric tube feeding group	128	38 [30]	90 [70]	70 [55]	58 [45]
Post-pyloric feeding group	117	24 [21]	93 [79]	47 [40]	70 [60]
Total	348	78 [22]	270 [78]	171 [49]	177 [51]
χ^2 value		6.941		5.787	
P value		0.031		0.055	

patients in the gastric tube feeding group had significantly higher proportions in terms of swallowing disorder and gastric retention than those in the oral feeding group and the post-pyloric feeding group. Patients in the post-pyloric

feeding group had statistically significantly higher rates of intra-abdominal hypertension, spontaneous cough and presence of mechanical ventilation than those in the oral feeding and gastric tube feeding groups ($P < 0.05$) (Table 4).

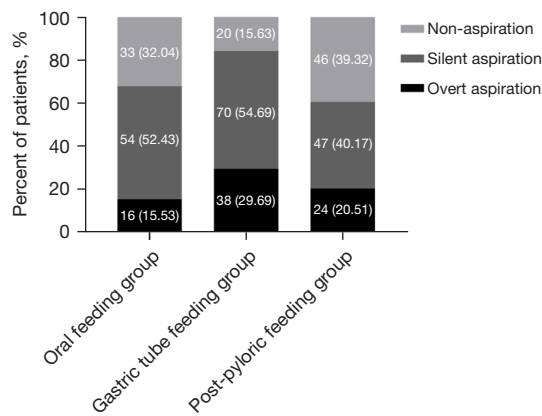


Figure 2 The proportion of three groups of aspiration types.

Comparison of silent aspiration characteristics in ICU elderly patients with different feeding patterns

Among patients with silent aspiration, the differences among the 3 groups were statistically significant ($P < 0.05$) in terms of impaired consciousness, swallowing disorder, vomiting, and mechanical ventilation (Table 5). The results of the two-way comparisons showed that the proportion of patients with impaired consciousness in the oral feeding group was lower than that in the post-pyloric feeding group, and the proportions of patients with vomiting and swallowing disorder were lower than that in the gastric tube feeding group. The proportion of patients with

Table 3 Comparison of characteristics of dominant aspiration in patients with different feeding patterns

Variables	Oral feeding group	Gastric tube feeding group	Post-pyloric feeding group	Test statistic	P value
Age (years)	69.19±4.02	70.74±4.21	71.17±2.84	1.390	0.255
Disorders of consciousness	5 [31]	23 [61]	13 [54]	3.906	0.142
Swallowing disorder	5 [31]	24 [63]	8 [33]	7.362	0.025
History of aspiration	9 [56]	13 [34]	11 [46]	2.417	0.299
Gastric retention	4 [25]	21 [55]	5 [21]	8.908	0.012
Intra-abdominal hypertension	4 [25]	14 [37]	15 [63]	6.438	0.040
Vomiting	5 [31]	13 [34]	6 [25]	0.588	0.745
Spontaneous cough	3 [19]	12 [32]	15 [63]	9.246	0.010
Gastrointestinal tumors	6 [38]	15 [39]	12 [50]	0.858	0.651
Mechanical ventilation	4 [25]	15 [39]	16 [67]	7.610	0.022
Intra-abdominal hypertension	4 [25]	14 [37]	15 [63]	6.438	0.040
Vomiting	5 [31]	13 [34]	6 [25]	0.588	0.745

Data are presented as mean ± SD or n [%]. SD, standard deviation.

Table 4 Pairwise comparison of characteristics of dominant aspiration in different groups (P value)

Group	Swallowing disorders	Gastric retention	Intra-abdominal hypertension	Spontaneous cough	Mechanical ventilation
Oral feeding group with gastric feeding group comparison	0.032	0.042	0.399	0.337	0.309
Oral feeding group with post-pyloric feeding groups comparison	0.890	0.757	0.020	0.006	0.010
Gastric feeding group with oral feeding group comparison	0.022	0.007	0.049	0.017	0.037

Table 5 Comparison of characteristics of micro-aspiration in patients with different feeding patterns

Group	Oral feeding group	Gastric tube feeding group	Post-pyloric feeding group	Test statistic	P value
Age (years)	70.19±2.95	69.93±3.67	69.96±2.80	0.108	0.898
Disordered consciousness	14 [26]	30 [43]	24 [51]	7.102	0.029
Swallowing disorder	9 [17]	26 [37]	14 [30]	6.292	0.043
History of aspiration	18 [33]	24 [34]	18 [38]	0.305	0.858
Gastric retention	9 [17]	16 [23]	10 [21]	0.744	0.689
Intra-abdominal hypertension	22 [41]	28 [40]	24 [51]	1.609	0.447
Vomiting	12 [22]	32 [46]	18 [38]	7.396	0.025
Spontaneous cough	16 [30]	32 [46]	26 [56]	7.043	0.03
Gastrointestinal tumors	21 [39]	36 [51]	21 [45]	1.955	0.376
Mechanical ventilation	20 [37]	22 [31]	26 [55]	6.946	0.031

Data are presented as mean ± SD or n [%]. SD, standard deviation.

Table 6 Pairwise comparison of characteristics of micro-aspiration in different groups (P value)

Group	Disorders of consciousness	Swallowing disorders	Vomiting	Spontaneous cough	Mechanical ventilation
Oral feeding group with gastric feeding group comparison	0.051	0.012	0.007	0.068	0.513
Oral feeding group with post-pyloric feeding groups comparison	0.009	0.117	0.078	0.009	0.066
Gastric feeding group with oral feeding group comparison	0.383	0.411	0.427	0.308	0.010

spontaneous cough was higher in the post-pyloric feeding group than in the oral feeding group, whereas in terms of mechanical ventilation, the proportion of patients was higher than that in the gastric tube feeding group, with statistically significant differences (all $P < 0.05$) (Table 6).

Independent risk factors for overt aspiration in ICU elderly patients

We performed a multiple logistic regression analysis of the 10 independent factors in the single-factor analysis and found that in the oral feeding group, swallowing disorders, history of aspiration, and gastrointestinal tumors had an effect on the occurrence of overt aspiration and were risk factors for it (Table 7; Figure 3A,3B), whereas in the gastric tube feeding group, we found that impaired consciousness, swallowing disorders, history of aspiration, and gastric retention significantly affected the incidence of overt aspiration (Table 8; Figure 3C,3D). In the post-pyloric

feeding group, age, mechanical ventilation, IAH, and spontaneous cough were independent risk factors for the occurrence of overt aspiration (Table 9; Figure 3E,3F).

Independent risk factors for silent aspiration in ICU elderly patients

We performed a multiple logistic regression analysis of the 10 independent factors in the single-factor analysis and found that age, history of aspiration, IAH, spontaneous cough, and gastrointestinal tumor had an effect on the occurrence of silent aspiration in the trans-pyloric feeding group and were risk factors for it (Table 7; Figure 3A,3B), whereas in the trans-pyloric feeding group, we found that history of aspiration, spontaneous cough, and gastrointestinal tumor significantly affected the incidence of silent aspiration. In the post-pyloric feeding group, mechanical ventilation, impaired consciousness, and IAH were independent risk factors for the occurrence of silent

Table 7 Multiple logistics regression of the oral feeding group

Group	Related factors	B	SE	Wald	P value	OR	95% CI	
							Lower	Upper
Overt aspiration	Age	0.047	0.128	0.135	0.713	1.048	0.815	1.348
	Mechanical ventilation	-0.646	1.006	0.412	0.512	0.524	0.073	3.765
	Disorders of consciousness	0.691	0.852	0.657	0.418	1.996	0.376	10.606
	Swallowing disorders	-3.052	1.303	5.486	0.019	0.047	0.004	0.608
	History of aspiration	-2.587	0.900	8.255	0.004	0.075	0.013	0.439
	Gastric retention	-0.608	0.990	0.378	0.539	0.544	0.078	3.787
	Intra-abdominal hypertension	-1.691	0.939	3.244	0.072	0.174	0.029	1.161
	Vomiting	-0.376	0.897	0.176	0.675	0.686	0.118	3.981
	Spontaneous cough	-1.383	1.123	1.515	0.218	0.251	0.028	2.268
	Gastrointestinal tumors	-2.301	1.048	4.820	0.028	0.100	0.013	0.781
Silent aspiration	Age	0.203	0.100	4.125	0.042	1.226	1.007	1.492
	Mechanical ventilation	-1.429	0.775	3.397	0.065	0.240	0.052	1.095
	Disorders of consciousness	0.582	0.661	0.775	0.379	1.790	0.49	6.537
	Swallowing disorders	-1.966	1.222	2.587	0.108	0.140	0.013	1.536
	History of aspiration	-1.584	0.778	4.148	0.042	0.205	0.045	0.942
	Gastric retention	-0.269	0.849	0.100	0.751	0.764	0.145	4.032
	Intra-abdominal hypertension	-2.183	0.762	8.207	0.004	0.113	0.025	0.502
	Vomiting	-0.088	0.759	0.013	0.908	0.916	0.207	4.052
	Spontaneous cough	-1.968	0.900	4.778	0.029	0.140	0.024	0.813
	Gastrointestinal tumors	-2.768	0.918	9.096	0.003	0.063	0.010	0.379

SE, standard error; CI, confidence interval; OR, odds ratio.

aspiration (Table 8; Figure 3C,3D).

Discussion

The incidence of aspiration is different in ICU elderly patients with different clinical features

Aspiration is a process in which a variable amount of food, oral secretions, or gastroesophageal reflux accidentally enters the airway under the voice box and the lungs during feeding due to lesions in the innervated motor nerves, which affect the function of the tongue muscles, soft palate, and pharynx (29). The occurrence of aspiration often leads to serious consequences, such as aspiration pneumonia, acute respiratory distress syndrome, pulmonary fibrosis, and even worse, death. Therefore, the clinical characteristics of each patient are different, and their probability of aspiration

is also different (30). According to our findings, there was a significant difference between the aspiration group and the non-aspiration group in terms of age, whether they were taking gastrointestinal motility drugs, and if they had been bedridden for a long time ($P < 0.05$). The incidence of aspiration was significantly higher in patients who were older, were not taking gastrointestinal motility drugs, and had a history of being bedridden for a long time.

The incidence of aspiration was different in ICU elderly patients with different feeding patterns

ICU patients are critically ill and have diverse and complex therapeutic measures. For critically ill elderly patients, early and reasonable gastrointestinal nutritional support can reduce protein depletion and malnutrition. Meanwhile, they

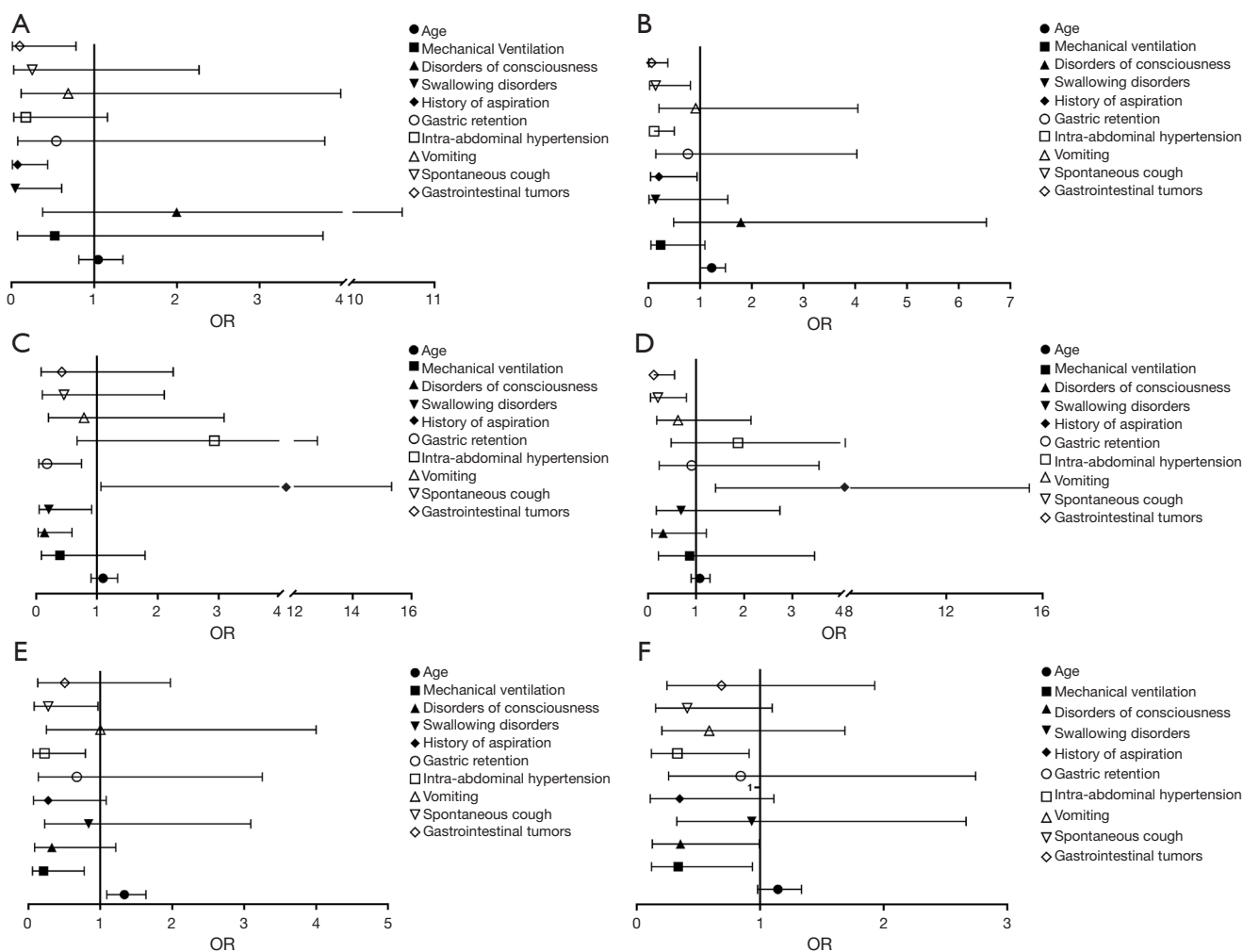


Figure 3 Multiple logistic regression of three groups. (A,B) Multiple logistic regression of the oral feeding group in overt and silent aspiration respectively; (C,D) multiple logistic regression of the gastric tube feeding group in overt and silent aspiration respectively; (E,F) multiple logistic regression of the post-pyloric feeding group in overt and silent aspiration respectively, OR, odds ratio.

also maintain the structure and function of the vital organs of the body (31). Therefore, nasal feeding has become the preferred mode of nutritional therapy for patients in the ICU. The results of this study showed that the differences in the incidence of overt aspiration among the oral feeding group, the gastric tube feeding group, and the post-pyloric feeding group were statistically significant ($P < 0.05$). The incidence of aspiration was higher in the gastric tube feeding group than in the other 2 groups for both overt and silent aspiration. Some studies (3,32) have shown that the incidence of aspiration in ICU patients ranges from 8.80% to 46.73%. In our study, the incidence of overt aspiration in the gastric tube feeding group was 29.5% and the incidence of silent aspiration was 55%, indicating that the incidence

of aspiration in elderly patients feeding through the gastric tube in ICU is still at a high level. The probability of overt aspiration and silent aspiration in the pyloric feeding group was lower than that in the gastric tube feeding group. This may be because nasogastric tube feeding requires the nutrient solution to be emptied through the stomach before entering the intestine, whereas the nasogastric tube nutrient solution can enter the intestine directly through the pylorus, effectively avoiding the occurrence of gastric retention due to gastric emptying obstacle. In addition, ICU patients not only receive nutrients through enteral nutrition, but also some of them receive nutrients through oral feeding, but there are few studies focusing on patients who receive nutrients through oral feeding (33). In our

Table 8 Multiple logistic regression of the gastric tube feeding group

Group	Related factors	B	SE	Wald	P value	OR	95% CI	
							Lower	Upper
Overt aspiration	Age	0.095	0.101	0.885	0.347	1.099	0.902	1.339
	Mechanical ventilation	-0.942	0.778	1.467	0.226	0.390	0.085	1.79
	Disorders of consciousness	-1.992	0.746	7.137	0.008	0.136	0.032	0.588
	Swallowing disorders	-1.579	0.759	4.331	0.037	0.206	0.047	0.912
	History of aspiration	1.396	0.681	4.206	0.040	4.038	1.064	15.326
	Gastric retention	-1.740	0.736	5.584	0.018	0.176	0.041	0.743
	Intra-abdominal hypertension	1.076	0.752	20046	0.153	2.931	0.671	12.799
	Vomiting	-0.242	0.699	0.120	0.729	0.785	0.2	3.089
	Spontaneous cough	-0.785	0.781	1.010	0.315	0.456	0.099	2.107
	Gastrointestinal tumors	-0.865	0.856	1.022	0.312	0.421	0.079	2.253
Silent aspiration	Age	0.072	0.092	0.619	0.432	1.075	0.898	1.288
	Mechanical ventilation	-0.141	0.706	0.040	0.841	0.868	0.218	3.465
	Disorders of consciousness	-1.161	0.691	2.818	0.093	0.313	0.081	1.215
	Swallowing disorders	-0.377	0.707	0.284	0.594	0.686	0.172	2.744
	History of aspiration	1.539	0.612	6.320	0.012	4.658	1.404	15.456
	Gastric retention	-0.098	0.698	0.020	0.888	0.907	0.231	3.557
	Intra-abdominal hypertension	0.626	0.691	0.821	0.365	1.871	0.482	7.253
	Vomiting	-0.473	0.630	0.563	0.453	0.623	0.181	2.143
	Spontaneous cough	-1.591	0.697	5.204	0.023	0.204	0.052	0.799
	Gastrointestinal tumors	-2.117	0.778	7.402	0.007	0.120	0.553	0.026

SE, standard error; CI, confidence interval; OR, odds ratio.

study, although the incidence of overt aspiration in the oral feeding group was only 15.5%, which was the lowest among the 3 groups, the incidence of silent aspiration was 52.4%, which was higher than that in the post-pyloric feeding group. Compared with the overt aspiration, the silent aspiration is insidious and difficult to diagnose, and may be more harmful to elderly patients than the overt aspiration. Therefore, health care professionals should pay attention to the problem of aspiration in elderly ICU patients who are fed orally, and it is necessary to assess the feeding ability of these patients and provide them with feeding education to minimize the possibility of aspiration and improve their prognosis.

The characteristics of overt aspiration were different in ICU elderly patients with different feeding patterns

In this study, analysis revealed that in the overt aspiration group, there were significant differences between the 3 groups in terms of whether the patients had swallowing disorders, gastric retention, IAH, whether they could cough spontaneously, and whether they needed mechanical ventilation ($P < 0.05$). A two-way comparison showed that among patients with dysphagia and gastric retention, there were significant differences between the gastric tube feeding group and the other 2 groups. The incidence of dysphagia and gastric retention in the gastric tube feeding group was significantly higher than in the other 2 groups. Among the

Table 9 Multiple logistic regression of the post-pyloric feeding group

Group	Related factors	B	SE	Wald	P value	OR	95% CI	
							Lower	Upper
Overt aspiration	Age	0.289	0.104	7.758	0.005	1.335	1.089	1.635
	Mechanical ventilation	-1.555	0.664	5.479	0.019	0.211	0.057	0.776
	Disorders of consciousness	-1.120	0.671	2.791	0.095	0.326	0.088	1.214
	Swallowing disorders	-0.178	0.667	0.071	0.789	0.837	0.226	3.092
	History of aspiration	-1.292	0.699	3.414	0.065	0.275	0.070	1.082
	Gastric retention	-0.397	0.804	0.243	0.622	0.673	0.139	3.253
	Intra-abdominal hypertension	-1.492	0.643	5.381	0.020	0.225	0.064	0.793
	Vomiting	0.001	0.707	0.000	0.999	1.001	0.250	4.000
	Spontaneous cough	-1.286	0.639	4.050	0.044	0.276	0.079	0.967
	Gastrointestinal tumors	-0.682	6.695	0.962	0.327	0.506	0.129	1.975
Silent aspiration	Age	0.133	0.079	2.847	0.092	1.143	0.979	1.334
	Mechanical ventilation	-1.092	0.524	4.340	0.037	0.336	0.120	0.937
	Disorders of consciousness	-1.038	0.527	3.886	0.049	0.354	0.126	0.994
	Swallowing disorders	-0.072	0.537	0.018	0.894	0.931	0.325	2.667
	History of aspiration	-1.057	0.592	3.184	0.074	0.348	0.109	1.110
	Gastric retention	-0.172	0.603	0.082	0.775	0.842	0.258	2.745
	Intra-abdominal hypertension	-1.113	0.520	4.578	0.032	0.329	0.911	0.119
	Vomiting	-0.532	0.538	0.979	0.322	0.587	0.204	1.686
	Spontaneous cough	-0.894	0.503	3.156	0.076	0.409	0.153	1.097
	Gastrointestinal tumors	-0.376	0.526	0.510	0.475	0.687	0.245	1.927

SE, standard error; CI, confidence interval; OR, odds ratio.

patients who could cough spontaneously or not and whether they needed mechanical ventilation, there were significant differences between the post-pyloric feeding group and other 2 groups, respectively. The percentage of patients who could not cough spontaneously and needed mechanical ventilation was significantly higher in the post-pyloric feeding group than in the other 2 groups. This may be due to the fact that ICU patients are in a critical condition, receive various and complex treatment measures, often require the placement of artificial airway catheters such as oropharyngeal ventilation tubes and tracheal intubation, as well as the use of enteral nutrition lines such as gastric and jejunal tubes, which artificially destroy the swallowing function and cough reflex of patients. The incidence of overt aspiration is significantly higher in ICU patients with dysphagia or requiring mechanical ventilation or are unable to cough on their own (34). Patients with overt aspiration often show symptoms such as irritant choking,

abnormal pronunciation, shortness of breath, and sudden drop in oxygen saturation, and in severe cases, cyanosis and dyspnea may occur, which endanger the safety of patients (3). In clinical work, especially in the ICU ward, mechanical ventilation and the use of gastric or intestinal tubes are more common, and the resulting aspiration is more easily ignored. Therefore, for elderly patients in the ICU, in addition to focusing on whether the patient has gastric retention and IAH, medical and nursing staff should promptly assess the patient's swallowing function and ability to cough on their own, and take targeted preventive measures early to reduce the occurrence of serious adverse consequences such as overt aspiration and aspiration pneumonia or even asphyxia.

The characteristics of silent aspiration were different in ICU elderly patients with different feeding patterns

The results of this study showed that among patients

with silent aspiration, there were significant differences between the 3 groups in terms of whether they had impaired consciousness, dysphagia, vomiting, whether they could cough spontaneously, and whether they needed mechanical ventilation ($P < 0.05$). The percentage of each characteristic was generally higher in the post-pyloric feeding group than in the oral feeding group, which was slightly different from the characteristics of the occurrence of overt aspiration. The results of the two-way comparison showed that in patients with impaired consciousness who were unable to cough spontaneously and were receiving mechanical ventilation, there was a significant difference between the post-pyloric feeding group and the other 2 groups ($P < 0.05$). In contrast, in the comparison between the oral feeding group and the gastric tube feeding group, the difference between the 2 features of dysphagia and vomiting was statistically significant in the 2 groups (both $P < 0.05$). The reason for this may be that when the patient is unconscious, the pharyngeal sensory perception is dulled and the swallowing function as well as the cough reflex is diminished or absent. In recent years, it has been shown that acquired swallowing disorders in ICU patients can be caused by disease, treatment, or other medical factors such as tracheal intubation. For example, 44–83% of mechanically ventilated patients have swallowing disorders after extubation (35,36). When patients have dysphagia or vomiting, food stays in the mouth for a long time and pharyngeal residues increase, resulting in accidental aspiration of food residues or oral secretions into the airway. The silent aspiration is often diagnosed only with the help of auxiliary means because of its insidious nature, and it has a certain lag, which may have a greater impact on the long-term prognosis of patients. Therefore, for these patients, medical and nursing staff should focus on whether patients fed through a gastric tube and orally are at high risk for silent aspiration, and dynamically assess the risk of silent aspiration in ICU patients with different feeding patterns in order to prevent occult aspiration at an early stage.

The risk factors of aspiration were different in ICU elderly patients with different feeding patterns

According to the study, the history of aspiration and gastrointestinal tumor were the common independent influencing factors for the occurrence on both overt and silent aspiration in the oral feeding group. In patients who experienced aspiration, their previous medical conditions were more severe, and they may have had sequelae such

as swallowing disorders, which may predispose them to secondary aspiration, especially during the process of oral feeding. The US consensus for nutritional assessment and supportive treatment of critically ill patients also state that the history of aspiration is a risk factor for aspiration (6). Therefore, patients with the history of aspiration should be screened and evaluated early in the clinical setting, and a high degree of attention should be paid to this group of patients to reduce the incidence of aspiration by slowing down the feeding rate according to their specific conditions. In addition, our findings suggest that gastrointestinal tumors are a common and independent risk factor for both overt and silent aspiration. The reason for this is that the distal end of the patient's intraoperative nasogastric tube needs to be delivered to the jejunum 25–30 cm below the anastomosis. When the tracheal tube or gastric tube is removed after surgery, the nasogastric tube may be taken out of its intended position due to improper operation or excessive force, and if the tip of the tube stays in the esophagus or is entangled in the stomach, there is a high possibility of regurgitation of nutrient solution during the infusion of enteral nutrition, leading to aspiration. The thicker the diameter of the catheter, the greater the dilating and opening effect on the lower esophageal sphincter, which makes it more likely that regurgitation of gastric contents will occur and lead to accidental aspiration (37). Therefore, for elderly patients with gastrointestinal tumors, the possibility of aspiration should be dynamically assessed and every effort should be made to avoid serious consequences.

In the gastric tube feeding group, in addition to history of aspiration as a common independent influencing factor for both overt and silent aspiration, impaired consciousness, dysphagia, and gastric retention were independent risk factors for overt aspiration, whereas spontaneous cough and gastrointestinal tumor were independent risk factors for silent aspiration. In the ICU, 80% of elderly people experience impaired consciousness (38). When patients experience disordered consciousness, the pharyngeal sensory perception is blunted, and the swallowing function as well as the cough reflex are weakened or lost, which makes it easy for aspiration to occur. Metheny *et al.* (39) found that a Glasgow Coma Scale (GCS) score < 9 ($P = 0.021$) was a risk factor for aspiration in a prospective study of factors influencing aspiration involving 360 ICU enteral nutrition patients. In a study of risk factors for aspiration in patients with impaired consciousness in carbon monoxide

poisoning, Sohn *et al.* (40) also concluded that a GCS score <8 was directly associated with aspiration in patients. Gastric retention is an important indicator to assess the tolerance of enteral nutrition and gastric emptying status of patients, and when the gastric retention reaches a certain threshold, it will cause an increase in intragastric pressure and intolerance such as nausea, vomiting, abdominal distention, and reflux of gastric contents, which will easily increase the risk of aspiration. This suggests that when patients have gastric retention, healthcare professionals should implement timely measures to monitor the amount of gastric residue; in severe cases, nasal feeding can be suspended to correct the patient's gastrointestinal dysfunction and effectively avoid the occurrence of aspiration. When spontaneous cough is weakened or absent, the patient's ability to clear respiratory secretions is also reduced, resulting in a large amount of secretions gathering in the respiratory tract and not being cleared in time, which can easily lead to aspiration. Therefore, for elderly patients in ICU, healthcare staff should encourage patients to cough as much as possible, so as to reduce the incidence of aspiration.

In the post-pyloric feeding group, mechanical ventilation and IAH were common independent influencing factors for the occurrence of both overt and covert aspiration. It has been shown that aspiration pneumonia due to aspiration accounts for 5–15% of hospitalized patients with pneumonia, and its mortality rate ranges from 20% to 65% (41,42). Mechanical ventilation is an effective measure commonly used in the clinical management of critically ill patients, which refers to the maintenance of patient airway patency, improvement of ventilation and oxygenation, and prevention of organismal hypoxia and carbon dioxide accumulation through ventilatory support (43). However, mechanical ventilation disrupts the patient's swallowing and coughing reflexes, making the patient unable to defend themselves through swallowing and coughing mechanisms, thus predisposing them to aspiration. Another important independent factor is IAH, which is defined as a sustained or repeated increase in intra-abdominal pressure (IAP) ≥ 12 mmHg; when IAP ≥ 20 mmHg is combined with organ dysfunction and failure, it is defined as abdominal compartment syndrome (ACS) (44). According to the survey, 50–80% of critically ill adult patients will develop IAH during treatment, and 2.7–51.7% of critically ill patients will further develop ACS (45). The abdominal pressure increases with the degree of abdominal distension, which affects the organ function. In addition, increased IAP

can lead to increased intestinal permeability and intestinal mucosal damage, which in turn affects the digestive and absorption functions of the intestine and further leads to reduced gastrointestinal motility and slowed gastric emptying. IAH can easily lead to gastric retention and gastrointestinal intolerance symptoms such as abdominal distention, vomiting, and gastric contents reflux, which in turn increases the risk of aspiration.

In conclusion, it is necessary to assess patients' ability to eat and provide them with pre-feeding education for oral feeding. For patients who are fed through the gastric tube or through the post-pylorus, the possibility of aspiration should be assessed according to the patient's condition and the presence of risk factors, and targeted measures such as encouraging voluntary coughing and gastrointestinal decompression should be taken in advance to reduce the possibility of aspiration.

The main shortcomings of this study were the insufficient case samples collected due to limited manpower and time, and the failure to follow up patient outcomes and survival. Future studies are recommended to expand the sample size and further follow-up of patients.

Conclusions

Among the elderly patients in the ICU, the incidence of aspiration, whether the overt or the silent was the highest in the gastric tube feeding group. There were significant differences in the influencing factors and characteristics of aspiration among the elderly patients in ICU with different feeding patterns. We should take personalized precautions early according to the characteristics and feeding patterns of patients, so as to reduce the possibility of aspiration.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Hai'an People's Hospital (No. KYLC2022036). Informed consent was provided by all patients.

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