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Tongue pressure during swallowing is an independent risk factor for aspiration pneumonia in middle-aged and older hospitalized patients: An observational study

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Aim: To evaluate oral frailty features present in hospitalized older patients with aspiration pneumonia.

Methods: We enrolled hospitalized patients aged ≥ 50 years and classified them into three groups: the community-acquired, aspiration, and non-community-acquired pneumonia groups. Oral frailty was defined as meeting three or more criteria from the following: choking, and decreased occlusal force, masticatory function, tongue–lip motor function, tongue pressure, and tongue pressure during swallowing.

Results: Of 168 patients enrolled, the incidence of aspiration pneumonia was 23.9% (17/71) in patients admitted with pneumonia as the primary diagnosis. The occlusal force and masticatory function were significantly poorer and tongue pressure and tongue pressure during swallowing were significantly lower in the aspiration pneumonia group than in the other two groups. A higher number of chronic comorbidities, poor oral health, and lower tongue pressure during swallowing were significantly associated with aspiration pneumonia. A tongue pressure during swallowing of <10.32 kPa might be a cutoff point for predicting the risk of aspiration pneumonia.

Conclusions: Hospitalized patients aged ≥ 50 years with multiple comorbidities, poor oral hygiene, and oral frailty during swallowing are at a higher risk of developing aspiration pneumonia, especially when their tongue pressure during swallowing is <10.32 kPa. Aspiration pneumonia is a preventable disease. Healthcare professionals should incorporate tongue pressure measurements or other screening tools into routine clinical practice to facilitate the early detection of this condition and intervention. *Geriatr Gerontol Int* 2024; 24: 351–357.

Keywords: aspiration, older adults, oral frailty, pneumonia.

Introduction

Pneumonia is an acute respiratory infection that Pneumonia is a form of acute respiratory infection that is most frequently caused for leading hospital admisso, particularly in older adults.¹ A global and regional systematic review conducted by a global collaboration including 109 eligible studies revealed that 6.8 million

*Trial registration: The Methods section of this study was registered in the US Registry of Clinical Trials on 01/27/2022 with IRCT ID: NCT 05407532 (Trial register: Chen, Yen-Chin); registration website: <https://classic.clinicaltrials.gov/ct2/show/NCT05407532>.

episodes of clinical pneumonia resulted in the hospital admission of older adults aged ≥ 65 worldwide.¹ Aspiration pneumonia is a type of pneumonia caused by the inhalation of oral or gastric contents. Komiya *et al.* conducted a systematic review and meta-analysis of 19 studies.² Their findings revealed a significant association between aspiration pneumonia and adverse outcomes in patients with community-acquired pneumonia. Specifically, patients with aspiration pneumonia had a 3.62 times higher in-hospital mortality rate compared with those without it, and a nearly 3.57 times higher 30-day mortality rate.²

Most cases of pneumonia in older adults are of aspiration pneumonia, which is often caused by the impairment of oropharyngeal function.³ This condition is characterized by various factors, such as diminished occlusal force owing to the loss of teeth,⁴ impaired tongue-lip motor function, reduced tongue pressure, and compromised chewing ability.⁵ Additionally, this leads to a compromised swallowing function.⁶ Collectively, these factors are referred to as oral frailty, as indicated by Tanaka.⁷ Oral frailty contributes to increased penetration, aspiration, and pharyngeal residue,⁸ ultimately leading to colonization of the oral cavity and subsequent aspiration.⁹ Teramoto *et al.* reported that the proportion of subjects with aspiration pneumonia among community-acquired and healthcare-associated pneumonia cases was 50%.³ The ratio of cases of aspiration pneumonia to the total number of cases of pneumonia in patients aged >50 years increased with age with each 10-year interval.¹⁰

Despite the strong association between various oropharyngeal functions and the development of aspiration pneumonia, a significant challenge exists in identifying older hospitalized individuals who have been diagnosed with pneumonia and may potentially have aspiration pneumonia. This challenge arises from the unclear diagnostic criteria and inconsistent definitions of aspiration pneumonia.¹¹ Understanding the link between pneumonia and oropharyngeal functions is crucial for healthcare professionals, as it can guide diagnosis, treatment, and preventive measures. For older adults and individuals with certain medical conditions, the careful monitoring of oropharyngeal functions and addressing any issues promptly can help reduce the risk of pneumonia, particularly of aspiration pneumonia. However, there is a lack of crucial information regarding the specific oral functions that can be targeted for prevention. Clinical studies have not yet provided conclusive evidence in this regard. This study aimed to investigate the association between oral frailty and the incidence of aspiration pneumonia in hospitalized older patients.

Methods

Study design and setting

This cross-sectional study was conducted in the internal medicine wards of a medical center in southern Taiwan from March 2022 to December 2022. The study was registered in the US Registry of Clinical Trials on 01/27/2022 with IRCT ID: NCT 05407532.

Participants

The selection of research participants in our study was motivated by the need to investigate the characteristics of oral frailty in a vulnerable population at risk of aspiration pneumonia. We identified our participants among newly admitted medical patients using electronic medical records, and all of them provided informed consent for their participation in the study. The inclusion criteria for this study were as follows: (1) age ≥ 50 years – this criterion was established as studies indicate that tongue muscle

deterioration often becomes more prominent after the age of 50;¹² and (2) a General Practitioner Assessment of Cognition score (assessing mental clarity) < 5 – advanced practice nurses (Yen-Chin Chen and En-Ni Ku) assessed participants' mental clarity using the General Practitioner Assessment of Cognition (GPCOG) scale.¹³ In our study, we carefully considered the inclusion criteria to focus on participants who did not have an existing risk for progressive oral functional decline. Those who had received treatment for oral diseases such as oral cancers or oral candidiasis in the previous 6 months, as well as patients with healthcare-associated pneumonia,¹⁴ were excluded.

We categorized all participants into three groups based on their primary admission diagnoses, which were evaluated by senior infectious disease doctors (Jiung-Ling Wang and Nan-Yao Lee), as follows.

1. Non-community-acquired pneumonia group: individuals diagnosed with conditions other than pneumonia, such as hepatobiliary, gastrointestinal, and infectious diseases, including fever and cellulitis.
2. Community-acquired pneumonia group: The diagnosis of pneumonia was established based on the following criteria: (a) the presence of acute lower respiratory symptoms such as fever, dyspnea, cough, sputum production, pleuritic chest pain, and loss of appetite; (b) at least one additional symptom such as fever or fatigue; and (c) radiographic evidence of lung infiltration observed on chest radiography or chest computed tomography,¹⁵ confirmed by an infectious diseases specialist.
3. Aspiration pneumonia group: Participants in this group met criteria similar to those of the community-acquired pneumonia group, with the additional requirement of a combination of clinical circumstances (such as individuals with risk factors for aspiration) and radiologic findings (including infiltrates in gravity-dependent lung segments in the appropriate location).¹⁶ Additionally, all enrolled participants underwent an extensive review of their choking history within the past 2 weeks, as well as screening for dysphagia and measurements of oral health after enrolment.

Power calculations were performed using the statistical software G-power, Heinrich-Heine-Universität Düsseldorf, Germany. 3.1.9.2. The parameters utilized for the correlation analysis consisted of an effect size of 0.50 (moderate), $\alpha = 0.05$, and a sample size of 168. Based on these calculations, the study exhibited a power of 0.99.

Measurements

Oral frailty

We modified the tool for the oral frailty assessment based on the results of Tanaka's study.⁷ The tool consists of the following six items for screening participants for oral frailty: (1) poor occlusal force, (2) poor masticatory function, (3) poor tongue-lip motor function, (4) low tongue pressure, (5) low tongue pressure during swallowing, and (6) experience of choking (Table S1.). Oral frailty was diagnosed if three or more of the above criteria were met. Oral frailty was assessed by accredited, trained oral assessment researchers (Yen-Chin Chen and En-Ni Ku).

Oral health

The Oral Health Assessment Tool (OHAT) is used as part of the best-practice oral health model for Australian residential care studies. The OHAT consists of eight items: lips, tongue, gums

and tissues, saliva, natural teeth, dentures, oral cleanliness, and dental pain. Each item is assessed on a scale of 0 (healthy) to 2 (unhealthy), with a higher score indicating poorer oral health. The reliability of the OHAT categories ranges from 72.6% to 92.6%.¹⁷ The Chinese version of the OHAT demonstrates acceptable internal consistency (Cronbach's $\alpha = 0.598$) and a significant intraclass correlation coefficient (ICC) (ICC = 0.868).¹⁸

Covariates

We collected data on the following variables from the electronic medical records: age, sex, educational level, length of hospital stays, number of comorbidities, comorbidities (hypertension/type 2 diabetes/chronic obstructive pulmonary disease (COPD)/cardiovascular diseases (CVDs)/stroke/cancer/hepatitis B, C/dementia/chronic renal failure/others), frequency of tooth brushing (times per day), and location of lung infiltration (upper/middle/lower).

Statistical analysis

Descriptive statistics, such as mean, standard deviation, number, and percentage, were used to describe the differences among the three groups. The incidence rate of aspiration pneumonia was calculated by using the number of participants diagnosed with pneumonia as the denominator, and the number of participants who developed aspiration pneumonia as the numerator. The χ^2 test with Fisher's exact test (for dichotomous variables) and one-way analysis of variance (ANOVA) were used to assess the differences in oral frailty and oral health among the three groups. Furthermore, a multivariate logistic regression model was used to investigate the correlations of aspiration and community-acquired pneumonia with oral frailty. Statistical significance was set at $P < 0.05$. Statistical analyses were performed using SPSS v.22.2 (IBM Corp, Armonk, NY, USA). This study was approved by the Ethics Committee of the institutional review board (IRB) (approval no. A-ER-109-426). We assessed the patients' oral health and frailty upon admission after obtaining informed consent from the participants.

Results

Demographic data

This study included 168 patients, with an average age of 68.73 ± 12.30 years at the time of enrollment. Patients were categorized into the three groups based on their diagnosis at admission: the non-community-acquired, community-acquired, and aspiration pneumonia groups contained 97 (57.7%), 54 (32.1%), and 17 (10.1%) patients, respectively. The incidence of aspiration pneumonia was 23.9% (17/71) in patients admitted with pneumonia as the primary diagnosis.

When comparing hospitalized patients with non-community-acquired and community-acquired pneumonia with those with aspiration pneumonia, several differences were observed. Patients with aspiration pneumonia tended to be older ($P = 0.001$), had longer hospital stays ($P = 0.011$), and had a higher prevalence of chronic comorbidities ($P = 0.001$), including CVDs ($P = 0.001$), stroke ($P = 0.019$), and cancer ($P = 0.003$). Additionally, the group with aspiration pneumonia exhibited a higher overall score for oral frailty ($P < 0.001$) (Table 1).

Differences in the six items of oral frailty measurement among the three groups

Of the enrolled patients, slightly more than half (58.3%) were diagnosed with oral frailty. Among the components of the oral

frailty assessment, tongue pressure, occlusal force, and masticatory function emerged as the three most problematic aspects among the participants.

Differences in each oral frailty item among the three groups were examined. The aspiration pneumonia group exhibited a notably poorer oral status than the other groups, particularly in poor tongue strength and difficulties in swallowing (Table 2).

Differences in the eight subscales of OHAT among the three groups

Differences in the mean oral health subscale scores among the three groups were analyzed using an ANOVA. The aspiration pneumonia group exhibited significantly poorer oral health compared with the non-community-acquired and community-acquired pneumonia groups (mean OHAT scores: 5.88 vs. 3.36 vs. 4.05, respectively, $P < 0.001$).

Further examination of the results from assessment on the eight components of OHAT among the three groups revealed significant differences related to the lips ($P < 0.001$), tongue ($P = 0.003$), and saliva ($P < 0.001$). The aspiration pneumonia group exhibited significantly poorer oral health than the other groups, particularly in relation to the lips, tongue, and saliva (Table 3).

Relationship between oral frailty and aspiration pneumonia in hospitalized patients

Multivariate logistic regression analysis revealed that a higher number of comorbidities (adjusted odds ratio [AOR] = 2.228, 95% confidence interval [CI], 1.198–4.141, $P = 0.011$), poor oral hygiene (AOR = 2.122, 95% CI, 1.331–3.382, $P < 0.001$), and a lower tongue pressure during swallowing (AOR = 0.827, 95% CI, 0.744–0.920, $P < 0.001$) were significantly associated with aspiration pneumonia. These findings indicate that the increased burden of comorbidities and reduced tongue pressure during swallowing are associated with a greater likelihood of developing aspiration pneumonia (Table 4). Receiver operating characteristic analysis showed that tongue pressure during swallowing < 10.32 kPa (area under the curve = 0.708, 95% CI, 0.612–0.805, $P < 0.001$) may serve as a predictive threshold for identifying individuals at high risk of developing aspiration pneumonia (Fig. 1).

Discussion

Owing to the shared mechanism between pneumonia and aspiration pneumonia, there is significant diagnostic overlap between the two conditions, particularly between aspiration pneumonia and community-acquired pneumonia. Our findings revealed that 23.9% of patients hospitalized with pneumonia were diagnosed with aspiration pneumonia: this is higher than the proportion suggested in a review, which found that aspiration pneumonia accounted for approximately 5–15% of cases of pneumonia among hospitalized individuals.^{19,20} However, our figure is much lower than the prevalence rate of 60.1% (264/439 cases) reported in a cross-sectional multicenter survey conducted in Japan among hospitalized patients with community-acquired pneumonia.¹⁰ It is important to acknowledge that our study had a relatively small sample size compared to previous studies. Furthermore, it is worth considering that previous research conducted using a retrospective design or relying on secondary data analysis may have played a role in underestimating the incidence of aspiration pneumonia.^{19,20} In addition, the inconsistency in results could be attributed to differences in participant characteristics and

Table 1 Characteristics of the hospitalized patients ($N = 168$)

Variable	<i>n</i> (%)				<i>P</i> -value
	Overall	Non-community-acquired pneumonia group ($n = 97$, 57.7%)	Community-acquired pneumonia group ($n = 54$, 32.1%)	Aspiration pneumonia group ($n = 17$, 10.1%)	
Age (years)	68.73, 12.30	66.06, 11.79	71.14, 12.73	76.35, 9.16	0.001
Sex					0.306
Male	100 (59.5)	56 (57.7)	36 (66.7)	8 (47.1)	
Female	68 (40.5)	41 (42.3)	18 (33.3)	9 (52.9)	
Level of education					0.236
Lower than college	90 (53.6)	57 (58.8)	23 (42.6)	10 (58.8)	
College and above	78 (46.5)	40 (41.2)	31 (57.4)	7 (41.2)	
Length of hospital stay (days)	7.94, 6.39	7.36, 4.87	7.63, 5.24	12.29, 13.06	0.011
Number of comorbidities	1.75, 1.23	1.58, 1.14	1.70, 1.25	2.82, 1.23	0.001
Comorbidities					
Hypertension	89 (53.0)	52 (53.6)	24 (44.4)	13 (76.5)	0.069
Type 2 diabetes	66 (39.3)	36 (37.1)	20 (37.0)	10 (58.8)	0.220
COPD	17 (10.1)	9 (9.3)	7 (13.0)	1 (5.9)	0.540
CVDs	34 (20.2)	13 (13.4)	12 (22.2)	9 (52.9)	0.001
Stroke	12 (7.1)	6 (6.2)	2 (3.7)	4 (23.5)	0.019
Cancer	32 (19.0)	12 (12.4)	12 (22.2)	8 (47.1)	0.003
Hepatitis B, C	7 (4.2)	6 (6.2)	1 (1.9)	0 (0.0)	0.293
Dementia	5 (3.0)	2 (2.1)	3 (1.8)	0 (0.0)	0.359
Chronic renal failure	22 (13.1)	10 (10.3)	9 (16.7)	3 (17.6)	0.455
Others	2 (1.2)	0 (0.0)	2 (3.7)	0 (0.0)	0.118
Frequency of tooth brushing (times/day)	1.69, 0.88	1.65, 0.68	1.63, 0.99	2.06, 1.14	0.186
Lung infiltration					
UP	17 (23.9%)	n/a	14 (25.9%)	3 (17.6%)	0.745
Middle	18 (25.4%)	n/a	15 (27.8%)	3 (17.6%)	0.531
Low	66 (93.0%)	n/a	49 (90.7%)	17 (100.0%)	0.328
Oral frailty score (mean, SD)	2.79, 1.51	2.39, 1.39	2.98, 1.47	4.47, 1.00	<0.001

COPD, chronic obstructive pulmonary disease; CVDs, cardiovascular diseases; n/a, not available; SD, standard deviation.

Table 2 Results of oral frailty assessment for the three groups

Variable	<i>n</i> (%)				<i>P</i> -value
	Overall	Non-community-acquired pneumonia group ($n = 97$)	Community-acquired pneumonia group ($n = 54$)	Aspiration pneumonia group ($n = 17$)	
Poor occlusal force	81 (48.2%)	38 (39.2%)	30 (55.6%)	13 (76.5%)	0.008
Number of teeth (mean, SD)	15.53, 10.52	16.43, 10.14	15.01, 11.26	13.17, 9.86	0.466
Low tongue pressure	111 (66.1%)	58 (59.8%)	38 (70.4%)	15 (88.2%)	0.053
Tongue pressure (kPa) (mean, SD)	23.62, 16.07	27.04, 16.00	20.19, 14.90	14.97, 15.30	0.002
Choking	49 (29.2%)	17 (17.5%)	15 (27.8%)	17 (100%)	<0.001
Tongue pressure during swallowing (kPa) (mean, SD)	14.29, 11.10	18.01, 11.46	9.94, 8.63	6.87, 6.69	<0.001
Poor tongue–lip motor function	60 (35.7%)	41 (42.3%)	15 (27.8%)	4 (23.5%)	0.111
Poor masticatory function	68 (40.5%)	32 (33.0%)	23 (42.6%)	13 (76.5%)	0.003
Oral frailty (overall score ≥ 3)	98 (58.3%)	48 (49.5%)	33 (61.1%)	17 (100.0%)	<0.001

SD, standard deviation.

the use of different tools (e.g., water swallowing test, simple swallowing provocation test, or videofluorography) to measure swallowing function.¹⁰ The incidence of aspiration pneumonia is high in community-acquired pneumonia, especially in older adults. Although antibiotic treatment is an effective strategy for treating pneumonia infections, it is crucial to implement a rapid screening strategy based on aspiration-related mechanisms to

prevent the development of pneumonia in hospitalized older adults.

The risk of aspiration pneumonia increases significantly in older populations, especially when coupled with inadequate oral health, multiple comorbidities, and frailty. Our findings are consistent with those of previous studies that demonstrated a correlation between aspiration pneumonia and improper oral hygiene

Table 3 Differences in the eight subscales of the OHAT among the three groups

Variable	Overall	Non-community-acquired pneumonia group (<i>n</i> = 97)	Community-acquired pneumonia group (<i>n</i> = 54)	Aspiration pneumonia group (<i>n</i> = 17)	<i>P</i> -value
Lips	0.24, 0.42	0.15, 0.36	0.27, 0.45	0.58, 0.50	<0.001
Tongue	0.61, 0.53	0.51, 0.52	0.70, 0.50	0.94, 0.55	0.003
Gums and tissues	0.17, 0.39	0.15, 0.36	0.16, 0.42	0.29, 0.46	0.413
Saliva	0.58, 0.70	0.37, 0.54	0.64, 0.73	1.52, 0.62	<0.001
Natural teeth	0.94, 0.82	0.90, 0.82	0.94, 0.83	1.11, 0.85	0.626
Dentures	0.19, 0.58	0.21, 0.61	0.20, 0.59	0.05, 0.24	0.581
Oral cleanliness	1.06, 0.74	1.00, 0.76	1.09, 0.70	1.29, 0.68	0.299
Dental pain	0.03, 0.18	0.04, 0.20	0.01, 0.13	0.05, 0.24	0.668
Total OHAT score	3.84, 1.95	3.36, 1.84	4.05, 1.82	5.88, 1.61	<0.001

OHAT, Oral Health Assessment Tool.

Table 4 Relationship between oral frailty and aspiration pneumonia in hospitalized patients

Variable	Aspiration pneumonia (ref. non-community-acquired pneumonia and community-acquired pneumonia)				
	β	Adjusted OR	95% confidence interval		P-value
			Lower	Upper	
Age	0.014	1.014	0.935	1.101	0.732
Female	1.164	3.204	0.695	14.777	0.135
Length of hospital stay	0.065	1.067	0.960	1.187	0.230
No. of comorbidities	0.801	2.228	1.198	4.141	0.011
Total OHAT score	0.752	2.122	1.331	3.382	0.002
Tongue pressure	0.075	1.077	0.999	1.162	0.054
Tongue pressure during swallowing	−0.190	0.827	0.744	0.920	<0.001
Chewing problem	0.805	2.237	0.381	13.147	0.373
Poor tongue–lip motor function	−1.224	0.294	0.049	1.765	0.181
Poor occlusal force	0.542	1.719	0.310	9.519	0.535

OHAT, Oral Health Assessment Tool.

behavior²¹ as well as the presence of multiple comorbidities.²² Regardless of age and existing medical conditions, there is a consistent association between pneumonia and oral health status as well as oral hygiene practices. These findings imply that improving the oral health of hospitalized older patients, particularly of those with multiple comorbidities, may reduce the risk of pneumonia.

Swallowing is a complex process that requires precise coordination of various muscles and structures, including the tongue. Tongue pressure refers to the force exerted by the tongue on the hard palate and other structures during swallowing. Impaired tongue pressure can result in ineffective bolus propulsion and incomplete oral clearance, thereby increasing the risk of aspiration.²³ Our data revealed that the median of tongue pressure in middle-aged and older hospitalized patients was 22.11 kPa. This finding appears to indicate lower tongue pressure values compared with the results from the Septuagenarians, Octogenarians, Nonagenarians Investigation with Centenarians (SONIC) study. Our study findings revealed lower tongue pressure compared to the SONIC study conducted in Japan, which investigated occlusal force and tongue pressure in a cohort of 951 followed-up community-dwelling advanced-age older people, as well as in a group of 750 participants who dropped out of the study. The SONIC study reported median tongue pressure for males and females aged 70–90 years in the follow-up group ranging from 24.0 to 29.5 kPa and from 23.4 to 27.5 kPa, respectively.²⁴ One possible explanation for this inconsistency is that hospitalization

represents a period of time when individuals are vulnerable and undergoing a greater deterioration owing to bed restrictions and unstable physical conditions, resulting in muscle power decline.²⁵ However, when comparing our study results with results for those who were lost to follow-up in the same study, our study findings were similar to those for community-dwelling people aged 90 years, with values ranging from 21.0 to 21.9 kPa.²⁴ This suggests that the interpretation of our findings aligns with previous research,²⁵ indicating that hospitalized patients exhibit not only greater physical frailty but also oral frailty.

In addition, a tongue pressure during swallowing of <10.32 kPa could serve as a predictive threshold for identifying individuals at high risk of developing aspiration pneumonia. Our findings align with those of a study by Sakamoto *et al.* (2022), namely that there is a higher incidence of pneumonia-related deaths among hospitalized older adults with reduced tongue pressure, particularly those diagnosed with dysphagia, with a mean tongue pressure of 7.75 kPa.²⁶ Similarly, Nakamori *et al.* (2016) demonstrated that patients with acute stroke with reduced tongue pressure were more likely to experience aspiration during swallowing, thereby increasing their vulnerability to pneumonia.²⁷ Although antibiotics are the standard treatment for pneumonia, they are insufficient for preventing aspiration pneumonia in patients with oral frailty. Healthcare professionals should prioritize the development of targeted interventions and preventive strategies to improve oral health and reduce the occurrence and impact of aspiration pneumonia.

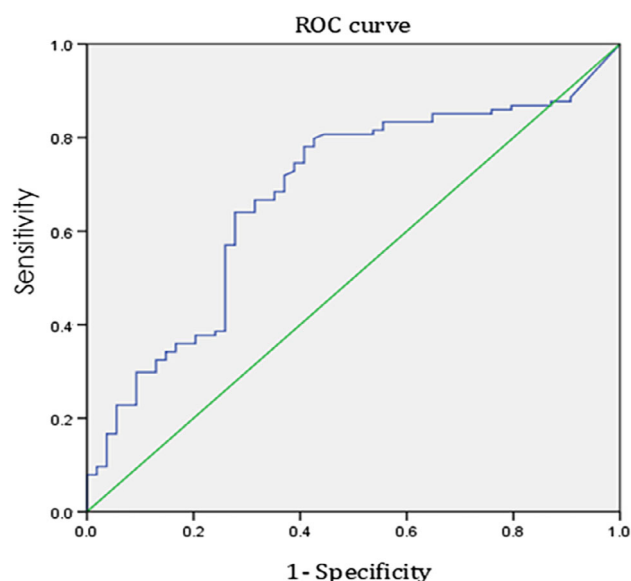


Figure 1 ROC curve for the optimal cutoff value for tongue pressure during swallowing for predicting aspiration pneumonia (AUC = 0.708, 95% CI, 0.612–0.805, $P < 0.001$). AUC, area under the curve; CI, confidence interval; ROC, receiver operating characteristic.

Oral health status plays a crucial role in the development and progression of pneumonia and aspiration pneumonia. Our data revealed that hospitalized patients with symptoms such as dry or red corners of the lips, poor tongue hygiene, or reduced saliva production are particularly vulnerable. Poor oral health, particularly dry mouth and inadequate tongue hygiene, can create an environment conducive for pathogenic bacteria in the oral cavity. These bacteria can then colonize the upper respiratory tract and eventually migrate to the lower respiratory tract, leading to infection.^{28,29} Our results are consistent with those of a previous study that included 40 hospitalized patients with dysphagia and demonstrated a relationship between low saliva levels, poor tongue cleanliness, and the presence of pathogenic oral bacteria.²⁹ A preliminary repeated observational study yielded similar results.²⁸ The prevention of aspiration pneumonia associated with oral bacteria requires a multidimensional approach.³⁰ Maintaining good oral hygiene practices, such as increasing the frequency of tooth brushing and seeking regular dental care, is crucial to prevent the development of aspiration pneumonia.

It is essential to recognize some limitations in this study. First, our study had a small sample size, potential confounding factors, and a cross-sectional design, which hinder the establishment of a causal relationship. Second, owing to the limitations imposed by a small sample size, conducting a sex-based comparison of tongue pressure was challenging. Further research, particularly through longitudinal studies, is necessary to gain a better understanding of the temporal relationship between the identified features of oral frailty and the development and progression of aspiration pneumonia.

Conclusions

Overall, 23.9% of hospitalized patients aged 50 years who were admitted with pneumonia were diagnosed with aspiration

pneumonia. Significantly increased oral frailty, including poor occlusal force and masticatory function and low tongue pressure and tongue pressure during swallowing, was observed in the aspiration pneumonia group compared with the non-aspiration pneumonia group. A tongue pressure during swallowing of <10.32 kPa might be an optimal cutoff point for predicting the risk for aspiration pneumonia. However, aspiration pneumonia can be prevented: maintaining good oral hygiene and regularly practicing oral exercises may help to improve oral function and prevent this condition.

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Disclosure statement

None.

Author contributions

C-YC, L-CW, T-PF, W-JL, Y-YF, K-NY, K-WC, and L-NY were responsible for the conceptualization and validation. C-YC, K-AE, Y-YF, W-JL, and L-NY completed the data collection and analysis. K-NY, K-WC and L-NY supervised the study. C-YC, K-AE and L-NY wrote the original draft of the manuscript. All authors reviewed and edited the manuscript.

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics statement

The study was approved by the Ethics Committee of institutional review board (IRB) (approval no. A-ER-109-426). All experiments were performed in accordance with the relevant guidelines and regulations (e.g., the Declaration of Helsinki). Informed consent was obtained from all participants prior to assessment of their oral health and frailty upon admission.

Consent for publication

Not applicable.

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website:

Supplementary Table S1. Six components of oral frailty used in this study.

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