

Original Article

Acupoint application combined with respiratory training for pulmonary function and readmission in patients with post-stroke pneumonia: a retrospective case-control study

Xiaoling Que^{1*}, Muqiong Su^{2*}, Fan Shen³, Xueping Ruan¹, Bowen Li¹, Zhengxia Liang⁴, Fagen Huang⁵

¹Geriatric Rehabilitation Department II, The Affiliated Rehabilitation Hospital of Fujian University of Traditional Chinese Medicine, Fuzhou, Fujian, China; ²Rehabilitation Medicine Department, Sanming Second Hospital, Yong'an, Fujian, China; ³Massage Department, The Affiliated Rehabilitation Hospital of Fujian University of Traditional Chinese Medicine, Fuzhou, Fujian, China; ⁴Cardiopulmonary Therapy Department, The Affiliated Rehabilitation Hospital of Fujian University of Traditional Chinese Medicine, Fuzhou, Fujian, China; ⁵Intensive Care Medicine Department, Beijing University of Traditional Chinese Medicine Shenzhen Hospital, Shenzhen, Guangdong, China.

*Equal contributors and co-first authors.

Received May 21, 2026; Accepted July 22, 2026; Epub October 15, 2026; Published October 30, 2026

Abstract: Objective: To evaluate the effect of acupoint application combined with respiratory training on pulmonary function and 6-month readmission in post-stroke pneumonia. Methods: This single-center retrospective case-control study enrolled 150 post-stroke pneumonia patients (January 2021-February 2025), divided into combined (acupoint application + respiratory training, n = 75) and control (respiratory training alone, n = 75) groups. Primary outcomes were changes in pulmonary function (Δ FVC, Δ FEV₁, Δ PEF) and 6-month readmission. Secondary outcomes included cure time, hospital stay, antibiotic duration, and CPIS improvement. Student's t-test, chi-square test, and L2-penalized logistic regression were used. Results: Baseline characteristics were balanced. The combined group showed greater improvements in Δ FVC (0.43 ± 0.14 vs. 0.22 ± 0.14 L), Δ FEV₁ (0.36 ± 0.12 vs. 0.15 ± 0.10 L), and Δ PEF (0.85 ± 0.30 vs. 0.34 ± 0.24 L/s) (all $P < 0.001$). Readmission was lower in the combined group (16.0% vs. 32.0%, $P = 0.035$), with combined intervention remaining an independent protective factor (OR = 0.378, 95% CI 0.163-0.876, $P = 0.023$). Cure time, hospital stay, and antibiotic use were shorter (all $P < 0.001$), and CPIS improvement ≥ 2 points was higher (92.0% vs. 78.7%, $P = 0.038$). Subgroup benefits favored PSI I-II, non-COPD, and moderate-to-severe dysphagia patients. Conclusion: Acupoint application plus respiratory training improves pulmonary function, shortens hospital stay, and independently reduces 6-month readmission in post-stroke pneumonia, warranting prospective validation.

Keywords: Post-stroke pneumonia, acupoint application, respiratory training, pulmonary function, hospital readmission, retrospective case-control study

Introduction

Post-stroke pneumonia is one of the most common infectious complications in stroke patients, with its incidence ranging from the type, severity, and diagnostic criteria of the stroke, ranging from 10% to 30% [1, 2]. The occurrence of post-stroke pneumonia is closely related to various factors such as consciousness disorders, impaired swallowing function, prolonged bed rest, weakened cough reflex, and immune suppression induced by the stroke [3]. Once pneu-

monia occurs, it not only prolongs hospital stay and increases costs but also elevates short-term mortality and long-term adverse prognosis of patients [4]. More importantly, post-stroke pneumonia patients face a high risk of respiratory infection recurrence after discharge, with approximately 20% to 30% of patients re-admitted to the hospital within 6 months after discharge due to pneumonia or acute lower respiratory tract infections [5]. Re-admission not only burdens the family and the medical system, but also impairs functional recovery of the

patients, forming a vicious cycle of “infection - re-admission - functional deterioration” [6]. Therefore, exploring intervention strategies that can effectively improve lung function and reduce the risk of long-term re-admission has become an urgent need in post-stroke respiratory rehabilitation. Given that the 6-month pneumonia-related readmission rate is a critical indicator of long-term treatment efficacy and healthcare resource utilization, we incorporated it as a primary endpoint in the present study.

Respiratory muscle training is one of the core non-pharmacological interventions in post-stroke pulmonary rehabilitation at present, usually including abdominal breathing, pursed-lip breathing, effective cough training, and respiratory muscle resistance training [7]. By enhancing the strength and endurance of the diaphragm and intercostal muscles, respiratory training can increase tidal volume, improve vital capacity and peak expiratory flow rate, and enhance expectoration ability and airway clearance function [8]. Randomized controlled trials and meta-analyses have confirmed that standardized respiratory training can significantly improve lung function indicators such as forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and maximum inspiratory pressure (MIP) in stroke patients [6, 9]. However, the benefits of respiratory training mainly lie in the aspect of ventilation mechanics, and its direct regulatory effect on airway inflammation and local immune function is limited. Therefore, whether it can further translate into a reduction in long-term clinical events (such as pneumonia recurrence, re-admission) remains insufficiently supported by evidence [10]. This also drives clinical researchers to explore the combined application of respiratory training with other intervention measures with anti-inflammatory or immune regulatory effects. The magnitude of improvement in key spirometric parameters - including forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and peak expiratory flow (PEF) - when respiratory training is combined with other modalities, remains to be fully characterized. Therefore, we selected changes in these parameters (ΔFVC , ΔFEV_1 , ΔPEF) as primary outcomes to quantify the incremental benefit of the combined intervention.

Acupoint application therapy is a typical representative of traditional Chinese medicine external treatment methods, based on the theoretical foundation of “treating internal diseases externally” in “The Yellow Emperor’s Inner Classic” and the theory of meridians [7]. The commonly used clinical formula consists primarily of *Semen Sinapis Albae* (Baijiezi/white mustard seed), *Radix et Rhizoma Asari* (Xixin/Chinese wild ginger), *Radix Euphorbiae Kansui* (Gansui/kansui root), and *Rhizoma Corydalis* (Yanhusuo/corydalis rhizome), which are ground into a fine powder, mixed with fresh ginger juice into a paste, and applied to the back-shu points and the key points of the Conception Vessel. In this formula, Baijiezi, pungent, warm, and dispersing, excels at expelling cold-phlegm from the skin, membranes, and exterior; Xixin, aromatic and penetrating, warms the lung and resolves retained fluid; Gansui, bitter, cold, and purgative, expels water and drains excess pathogens from the lung; and Yanhusuo, which moves qi and invigorates blood, assists the other medicinals in penetrating the skin and reaching the collaterals. The four medicinals used together achieve the combined effects of warming the lung to resolve phlegm, diffusing and unblocking lung qi, and activating blood to free the collaterals [8]. In terms of acupoint selection, Feishu (BL13) is the key back-shu point where the lung meridian qi is infused into the back, and Dingchuan (EX-B1) is an extra-meridian point. The combination of these two points can diffuse and descend lung qi, relieve cough, and calm dyspnea. Tiantu (CV22), located in the suprasternal fossa, belongs to the Conception Vessel and functions to disseminate lung qi, benefit the throat, restore voice, and resolve phlegm to relieve cough. Danzhong (CV17) is the influential point of qi, which can widen the chest, disinhibit the diaphragm, and descend qi to resolve phlegm. The combined use of these four points, with back-shu points corresponding to the chest and abdomen, forms a holistic regulatory pattern known as “front-back acupoint combination” [11]. Modern studies have shown that acupoint application can reduce the frequency of acute exacerbations in patients with chronic obstructive pulmonary disease (COPD) and bronchial asthma, improve lung function indicators, and lower serum inflammatory factor levels [12]. The possible mechanisms of its action include: the drug penetrates through the skin and directly acts

on the local airways and lung tissues, reducing airway inflammation and excessive mucus secretion; at the same time, it stimulates acupoints, meridians, and internal organs' reflex pathways to regulate the autonomic nerve function and improve the tension of bronchial smooth muscle [13, 14]. However, the application of acupoint patches in patients with pneumonia after acute stroke is still in its infancy, and whether its combination with respiratory training can produce a synergistic effect and reduce the risk of long-term readmission currently lacks direct evidence.

From a theoretical perspective, respiratory training focuses on improving ventilation function through biomechanical pathways, while acupoint patches focus on regulating the local immune and inflammatory state of the lungs through drug and meridian pathways. The combination of the two may achieve complementary and synergistic effects of "ventilation improvement" and "inflammation control" [15]. However, this hypothesis has not yet been rigorously clinically verified in the specific population of post-stroke pneumonia. In addition, although some studies have separately explored the effects of respiratory training or acupoint patches on post-stroke pulmonary function, most of these studies have small sample sizes, limited observation indicators to the pulmonary function parameters during hospitalization, and lack of assessment of long-term clinical endpoints such as readmission [16, 17]. In the context where reducing unplanned readmission has become an important assessment indicator for medical quality [14], including the readmission rate as a research endpoint is of high practical significance for evaluating the clinical value of combined intervention. Additionally, in-hospital outcomes such as clinical cure time, length of hospital stay, antibiotic duration, and the proportion of patients achieving at least a 2-point improvement in the Clinical Pulmonary Infection Score (CPIS) were selected as secondary endpoints to provide a comprehensive assessment of the intervention's impact on the acute care process.

Based on the above background, this study adopted a retrospective case-control design to evaluate the impact of acupoint patches combined with respiratory training on pulmonary function and long-term readmission in patients

with post-stroke pneumonia, with the aim of providing clinical evidence for the combined Chinese and Western strategies of post-stroke pulmonary rehabilitation.

Materials and methods

Research design

This was a single-center retrospective case-control study. The study protocol was approved by the Medical Ethics Committee of the Affiliated Rehabilitation Hospital of Fujian University of Traditional Chinese Medicine, and the requirement for informed consent was waived. All procedures performed in this study involving human participants were in accordance with the Declaration of Helsinki (as revised in 2013).

Research subjects

The patients with post-stroke pneumonia who were admitted from January 2021 to February 2025 were retrieved through the electronic medical record system. Inclusion criteria: (I) Confirmed as ischemic or hemorrhagic stroke by head CT or MRI, and developed pneumonia during hospitalization (meeting the CDC pneumonia diagnostic criteria: new or progressive infiltrates on imaging accompanied by at least two infection-related clinical manifestations or laboratory abnormalities); (II) Age ≥ 18 years; (III) Clear consciousness, Glasgow Coma Scale score of 15, and able to cooperate with pulmonary function measurement; (IV) Had respiratory training records during hospitalization (≥ 5 times); (V) Complete medical records and traceable key outcome indicators.

Exclusion criteria: (I) Complicated with severe heart, liver, or kidney dysfunction; (II) Death or automatic discharge during hospitalization resulting in missing outcome data; (III) Complicated with pneumothorax, severe asthma or severe deformity of the thorax; (IV) Skin ulceration at the acupoint application site or clear contraindications.

According to whether acupoint application therapy was combined with respiratory training in the medical record system, the included patients were divided into the combined group (acupoint application + respiratory training)

and the control group (simple respiratory training). The exposure of acupoint application was defined as: there was a clear record of acupoint application treatment during hospitalization, the selected acupoints included bilateral Feishu (BL13), Dingchuan (EX-B1), Tiantu (CV22), Danzhong (CV17), and the drug composition was prepared from Radix Notopterygii, Asarum, Troglodytes, Curculigo, etc., and a cumulative of ≥ 3 applications were completed.

Data collection

The following information was retrospectively extracted through the electronic medical record system: (I) Baseline data at admission: age, gender, stroke type (ischemic/hemorrhagic), National Institutes of Health Stroke Scale (NIHSS) score, smoking status, comorbidities (hypertension, diabetes, atrial fibrillation, history of previous stroke, coronary heart disease, COPD), degree of dysphagia, PSI pneumonia severity index grading; (II) Laboratory test results within 48 hours of admission: serum albumin, CRP, PCT; (III) Pulmonary function parameters within 48 hours of admission and before discharge: FVC, FEV₁, FEV₁/FVC, PEF, all collected from portable pulmonary function instrument records; (IV) Clinical information during hospitalization: respiratory training and acupoint application execution records, antibiotic use, clinical recovery time (normalization of body temperature and white blood cell count, CRP, and no need for oxygen inhalation after discharge); (V) Records of re-admission to our center within 6 months after discharge due to pneumonia or acute lower respiratory tract infection, obtained through the hospital information platform and re-admission registration system. All records were cross-checked.

Outcome indicators

The main outcome indicators were the changes in pulmonary function parameters at discharge compared to baseline (Δ FVC, Δ FEV₁, Δ PEF) and the re-hospitalization rate for pneumonia-related conditions within 6 months after discharge. Secondary outcome indicators included: clinical recovery time, total hospitalization days, antibiotic use days, and the proportion of patients with a decrease of ≥ 2 points in CPIS during hospitalization.

Statistical methods

As this was a retrospective study, sample size was not pre-calculated. A post-hoc power analysis based on Δ FVC showed that with 75 patients per group, the observed effect size (Cohen's $d = 1.500$) yielded a statistical power exceeding 99% ($\alpha = 0.05$, two-sided), indicating sufficient power to detect the primary outcome.

Continuous data are presented as mean $\pm$ standard deviation and were compared using the independent samples t-test; non-normally distributed data are presented as median (interquartile range) and were compared using the Mann-Whitney U test. Categorical data are expressed as counts (percentages) and were analyzed using the χ^2 test or Fisher's exact test. Standardized mean differences (SMDs) were calculated to assess baseline covariate balance. Univariate and multivariable logistic regression analyses were performed to identify independent risk factors for 6-month readmission; given the limited number of outcome events, the multivariable model employed L2-penalized regression to ensure convergence. Pre-specified subgroup analyses were stratified by PSI grade, dysphagia severity, COPD status, and age (< 65 vs. ≥ 65 years), with rate differences and their 95% confidence intervals calculated. The 65-year cutoff was selected because it is the most widely used threshold for defining the elderly population in stroke research and aligns with the age classification in the PSI score and the Chinese standard for elderly care [18]. All tests were two-sided, with $P < 0.05$ considered statistically significant. Analyses were conducted using SPSS 26.0 and Python 3.13.

Results

Patient screening process and baseline characteristics

A total of 150 patients meeting the criteria for post-stroke pneumonia were finally included in the study, including 75 patients in the control group (simple respiratory training) and 75 patients in the combined group (acupoint application combined with respiratory training). The patient screening process is shown in **Figure 1**.

The comparison of baseline demographic, clinical characteristics and pre-treatment variables

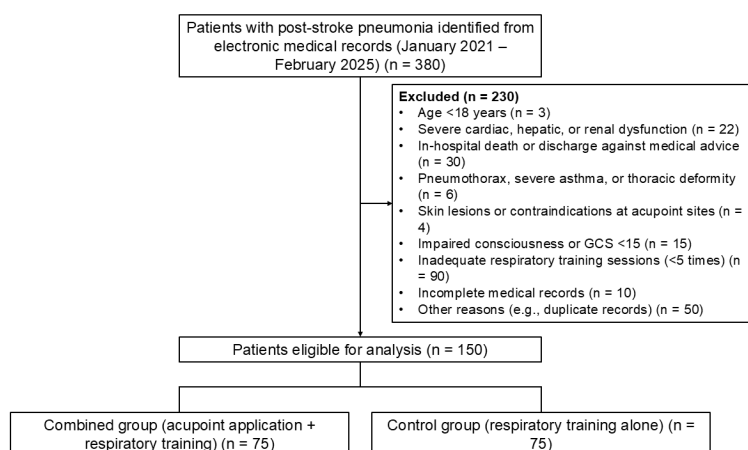


Figure 1. Flow chart of patient selection.

between the two groups is presented in **Table 1**. There were no statistically significant differences in age, gender, stroke type, smoking status, comorbidities (hypertension, diabetes, atrial fibrillation, previous stroke, coronary heart disease, COPD), degree of dysphagia and PSI grade between the control group and the combined group (all $P > 0.05$). Only the NIHSS score of the combined group was slightly higher than that of the control group (6.79 ± 2.82 vs. 5.81 ± 2.82 , $P = 0.036$). The standardized mean differences (SMD) before matching are shown in **Figure 2**. The SMD values of most variables were less than 0.2, suggesting that the baseline of the two groups was overall balanced and comparable.

Changes in pulmonary function

The changes in pulmonary function parameters before and after treatment are listed in **Table 2**, and the box plots of the change values are shown in **Figure 3**. The change value of forced vital capacity (ΔFVC) in the combined group was 0.43 ± 0.14 L, significantly higher than that of the control group (0.22 ± 0.14 L), and the difference was statistically significant ($t = -8.742$, $P < 0.001$). The change value of forced expiratory volume in one second (ΔFEV_1) in the combined group was also better than that of the control group (0.36 ± 0.12 L vs. 0.15 ± 0.10 L, $t = -11.497$, $P < 0.001$). The change value of peak expiratory flow rate (ΔPEF) in the combined group was 0.85 ± 0.30 L/s, while that in the control group was 0.34 ± 0.24 L/s, and the difference was statistically significant ($t = -11.645$, $P < 0.001$). Although there was a sta-

tistically significant difference in the change value of FEV_1/FVC ratio ($P = 0.016$), the absolute change amplitude was extremely small.

6-month readmission rate

The 6-month pneumonia-related readmission rates are shown in **Figure 4** and **Table 3**. The readmission rate of the combined group was 16.0% (12/75), while that of the control group was 32.0% (24/75). The combined intervention reduced the absolute risk of readmission by 16.0 percent-

age points, and the difference was statistically significant ($\chi^2 = 4.423$, $P = 0.035$).

Clinical indicators during hospitalization

The clinical indicators during hospitalization are detailed in **Table 3**. The clinical recovery time (8.81 ± 3.13 days vs. 11.93 ± 3.54 days, $t = 5.719$, $P < 0.001$), total hospitalization days (10.95 ± 3.38 days vs. 13.64 ± 3.74 days, $t = 4.626$, $P < 0.001$) and antibiotic use days (7.57 ± 1.95 days vs. 10.21 ± 2.70 days, $t = 6.864$, $P < 0.001$) in the combined group were shorter than those in the control group, and the differences were statistically significant. In addition, the proportion of patients with a decrease of ≥ 2 points in CPIS in the combined group was higher than that in the control group (92.0% vs. 78.7%, $\chi^2 = 4.315$, $P = 0.038$).

Multivariate analysis of factors influencing readmission

To correct for potential confounding factors, Logistic regression analysis was used to identify the independent influencing factors of readmission. The results are presented in **Table 4**. The univariate regression showed that the combined intervention was associated with a reduced risk of readmission (OR = 0.405, 95% CI 0.187-0.878, $P = 0.035$). After correcting for PSI grade, moderate to severe dysphagia, COPD and age using L2 penalized multivariate regression, the combined intervention remained an independent protective factor for readmission (OR = 0.378, 95% CI 0.163-0.876, $P = 0.023$). In this multi-factor model, the OR

Table 1. Baseline characteristics of the study cohort (n = 150)

Variable	Control (n = 75)	Combined (n = 75)	t/ χ^2	P value
Age, years	65.85 $\pm$ 8.61	66.64 $\pm$ 10.57	-0.500	0.618
NIHSS score	5.81 $\pm$ 2.82	6.79 $\pm$ 2.82	-2.115	0.036
Albumin, g/L	44.93 $\pm$ 2.78	44.48 $\pm$ 2.70	1.001	0.319
CRP, mg/L	68.99 $\pm$ 41.59	62.62 $\pm$ 45.72	0.894	0.373
PCT, ng/mL	2.14 $\pm$ 1.75	2.66 $\pm$ 2.69	-1.409	0.161
Gender, n (%)			0.245	0.620
Male	45 (60.0%)	41 (54.7%)		
Female	30 (40.0%)	34 (45.3%)		
Stroke type, n (%)			0.342	0.559
Ischemic	56 (74.7%)	60 (80.0%)		
Hemorrhagic	19 (25.3%)	15 (20.0%)		
Smoking status, n (%)			5.257	0.072
Never	25 (33.3%)	38 (50.7%)		
Former	20 (26.7%)	18 (24.0%)		
Current	30 (40.0%)	19 (25.3%)		
Hypertension, n (%)			0.000	1.000
No	30 (40.0%)	30 (40.0%)		
Yes	45 (60.0%)	45 (60.0%)		
Diabetes, n (%)			0.181	0.671
No	60 (80.0%)	63 (84.0%)		
Yes	15 (20.0%)	12 (16.0%)		
Atrial fibrillation, n (%)			0.419	0.518
No	60 (80.0%)	64 (85.3%)		
Yes	15 (20.0%)	11 (14.7%)		
Prior stroke, n (%)			0.000	1.000
No	65 (86.7%)	65 (86.7%)		
Yes	10 (13.3%)	10 (13.3%)		
Coronary artery disease, n (%)			1.247	0.264
No	59 (78.7%)	52 (69.3%)		
Yes	16 (21.3%)	23 (30.7%)		
COPD, n (%)			0.265	0.606
No	68 (90.7%)	65 (86.7%)		
Yes	7 (9.3%)	10 (13.3%)		
Dysphagia grade, n (%)			5.345	0.148
None	10 (13.3%)	7 (9.3%)		
Mild	46 (61.3%)	36 (48.0%)		
Moderate	17 (22.7%)	30 (40.0%)		
Severe	2 (2.7%)	2 (2.7%)		
PSI grade, n (%)			2.391	0.664
I	49 (65.3%)	43 (57.3%)		
II	22 (29.3%)	26 (34.7%)		
III	1 (1.3%)	3 (4.0%)		
IV	2 (2.7%)	1 (1.3%)		
V	1 (1.3%)	2 (2.7%)		

Abbreviations: NIHSS, National Institutes of Health Stroke Scale; CRP, C-reactive protein; PCT, procalcitonin; COPD, chronic obstructive pulmonary disease; PSI, Pneumonia Severity Index.

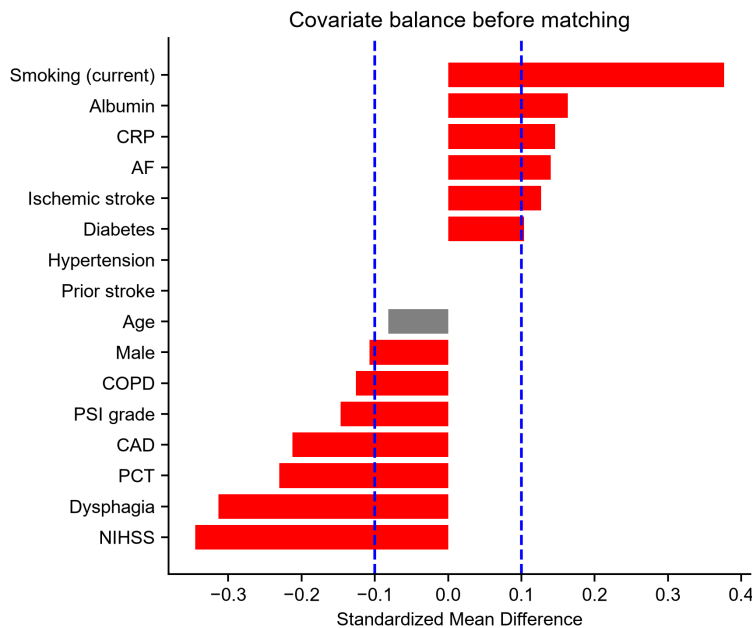


Figure 2. Standardized mean differences of baseline covariates before matching (n = 150; 75 per group). Abbreviation: SMD, standardized mean difference.

Table 2. Pulmonary function at baseline and discharge

Variable	Control (n = 75)	Combined (n = 75)	t	P value
FVC, baseline, L	2.65 ± 0.58	2.61 ± 0.63		
FVC, discharge, L	2.88 ± 0.60	3.04 ± 0.66		
ΔFVC, L	0.22 ± 0.14	0.43 ± 0.14	-8.742	< 0.001
FEV ₁ , baseline, L	1.99 ± 0.54	1.92 ± 0.53		
FEV ₁ , discharge, L	2.14 ± 0.57	2.27 ± 0.53		
ΔFEV ₁ , L	0.15 ± 0.10	0.36 ± 0.12	-11.497	< 0.001
PEF, baseline, L/s	5.00 ± 1.22	4.68 ± 1.25		
PEF, discharge, L/s	5.34 ± 1.23	5.54 ± 1.29		
ΔPEF, L/s	0.34 ± 0.24	0.85 ± 0.30	-11.645	< 0.001
FEV ₁ /FVC, baseline	0.74 ± 0.13	0.73 ± 0.11		
FEV ₁ /FVC, discharge	0.74 ± 0.13	0.75 ± 0.11		
ΔFEV ₁ /FVC	-0.00 ± 0.05	0.02 ± 0.06	-2.438	0.016

Abbreviations: FVC, forced vital capacity; FEV₁, forced expiratory volume in 1 second; PEF, peak expiratory flow.

for each increase in PSI level was 1.474 (95% CI 0.885-2.453, P = 0.136), the OR for moderate to severe dysphagia was 1.353 (95% CI 0.581-3.153, P = 0.483), the OR for COPD was 1.205 (95% CI 0.328-4.430, P = 0.779), and the OR for each 10-year increase in age was 1.257 (95% CI 0.744-2.124, P = 0.392). Although these covariates did not reach statistical significance, they all showed a trend of increased readmission risk.

Subgroup analysis

After stratification by PSI grade, degree of dysphagia, presence of COPD, and age, the readmission rates and rate differences of each subgroup are shown in **Table 5**, and the corresponding forest plots are shown in **Figure 5**. In the PSI II subgroup (140 cases), the readmission rate of the combined group was 13.0%, which was lower than 29.6% of the control group (rate difference -16.5%, P = 0.023). In the subgroup without COPD (133 cases), the readmission rate of the combined group was 13.8%, which was also lower than 30.9% of the control group (rate difference -17.0%, P = 0.023). The rate difference of the moderate to severe dysphagia subgroup (51 cases) was -26.5% (P = 0.050). The rate differences of the other subgroups were all consistent in favor of the benefits of combined intervention, but the differences did not reach statistical significance.

Association between lung function and clinical recovery

To evaluate the impact of baseline lung function on treatment response, we plotted the relationship between baseline pulmonary function parameters (FEV₁, FVC, and PEF) and clinical recovery time of the two groups (**Figure 6A-C**). All three indicators showed consistent

negative correlation trends, with higher baseline values associated with shorter clinical recovery time. Across all three parameters, the fitted regression lines of the combined group were consistently below those of the control group, indicating that at the same baseline lung function level, patients receiving the combined intervention achieved clinical recovery approximately 4.8 to 5.9 days earlier than those receiving respiratory training alone (based on the

Acupoint application plus respiratory training in post-stroke pneumonia

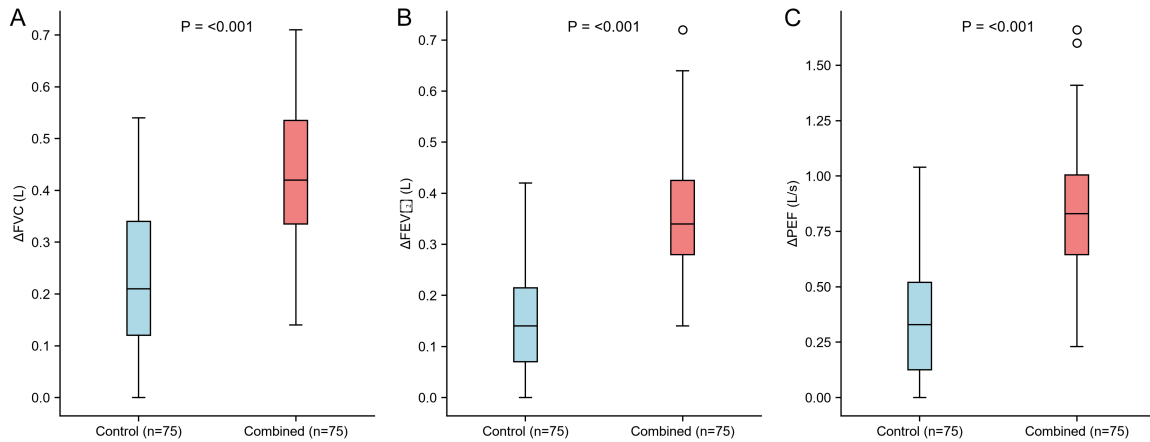


Figure 3. Box plots of pulmonary function changes from baseline in the two groups. A. Change in forced vital capacity (ΔFVC). B. Change in forced expiratory volume in 1 second (ΔFEV_1). C. Change in peak expiratory flow (ΔPEF). Abbreviations: FVC, forced vital capacity; FEV_1 , forced expiratory volume in 1 second; PEF, peak expiratory flow.

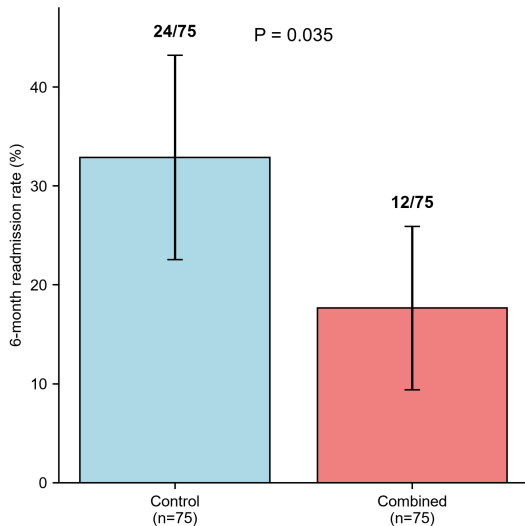


Figure 4. Bar chart comparing 6-month pneumonia-related readmission rates between the two groups.

intercept differences in the fitted regression models for FEV_1 , FVC, and PEF). These findings collectively support that the combined intervention may accelerate clinical rehabilitation through improving ventilatory function, and the consistency across FEV_1 , FVC, and PEF reinforces the robustness of this association.

Efficacy observation under different severity levels of pneumonia

We further analyzed the achievement of CPIS improvement of ≥ 2 points in the two groups of patients under different PSI grades (**Figure 7**).

In PSI grade I patients, the CPIS improvement rate of the combined group was as high as 97.7%, while that of the control group was 77.6%, suggesting that patients with mild pneumonia may benefit more significantly from the combined intervention. The improvement rates of the two groups in PSI grade II were similar (84.6% vs. 86.4%). Due to the small sample size in PSI III-V grades (only 1-3 cases in each grade), the results were highly variable and insufficient for reliable statistical analysis. This stratified result is only for descriptive reference and needs to be further verified by large-sample studies.

Discussion

This study evaluated the effects of acupoint application combined with respiratory training in patients with post-stroke pneumonia. The key findings were threefold: (1) significant improvements in FVC, FEV_1 , and PEF at discharge; (2) a 16-percentage-point absolute risk reduction in 6-month readmission; and (3) shorter hospital stay, shorter antibiotic duration, and a higher CPIS improvement rate. These results suggest that the combination therapy may offer benefits across multiple clinically relevant dimensions.

We analyzed the synergistic mechanism of pulmonary function improvement. In this study, the ΔFVC , ΔFEV_1 , and ΔPEF in the combined group reached 0.43 L, 0.36 L, and 0.85 L/s respectively, showing a significantly greater

Table 3. Secondary outcomes

Variable	Control (n = 75)	Combined (n = 75)	t/ χ^2	P value
Cure time, days	11.93 $\pm$ 3.54	8.81 $\pm$ 3.13	5.719	< 0.001
LOS, days	13.64 $\pm$ 3.74	10.95 $\pm$ 3.38	4.626	< 0.001
Antibiotic days	10.21 $\pm$ 2.70	7.57 $\pm$ 1.95	6.864	< 0.001
CPIs improvement $\geq$ 2	59 (78.7%)	69 (92.0%)	4.315	0.038
6-month readmission	24 (32.0%)	12 (16.0%)	4.423	0.035

Abbreviations: LOS, length of stay; CPIs, Clinical Pulmonary Infection Score.

Table 4. Logistic regression for 6-month readmission

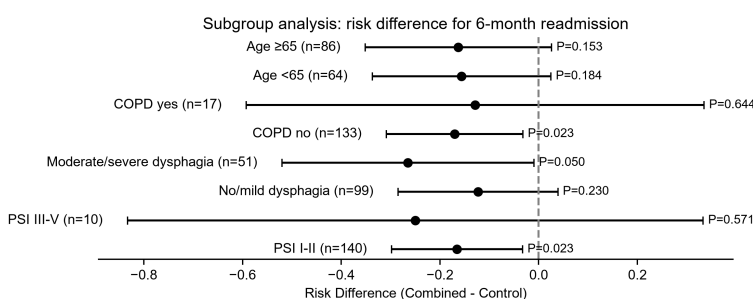
Model	Variable	β	SE	OR (95% CI)	Statistic (z)	P value
Univariate	Group (Combined vs. Control)			0.405 (0.187-0.878)		0.035
Multivariate*	Group (Combined vs. Control)	-0.974	0.429	0.378 (0.163-0.876)	-2.268	0.023
Multivariate*	PSI grade (per 1 level)	0.388	0.260	1.474 (0.885-2.453)	1.491	0.136
Multivariate*	Dysphagia severe	0.302	0.432	1.353 (0.581-3.153)	0.701	0.483
Multivariate*	COPD	0.186	0.664	1.205 (0.328-4.430)	0.280	0.779
Multivariate*	Age per 10 years	0.229	0.268	1.257 (0.744-2.124)	0.856	0.392

*L2-penalized logistic regression. Abbreviations: OR, odds ratio; CI, confidence interval; PSI, Pneumonia Severity Index; COPD, chronic obstructive pulmonary disease; SE, standard error.

Table 5. Subgroup analysis of 6-month readmission

Subgroup	Total N	Control readm. rate	Combined readm. rate	Absolute difference	P value (Fisher)
PSI I-II	140	29.6% (71)	13.0% (69)	-16.5%	0.023
PSI III-V	10	75.0% (4)	50.0% (6)	-25.0%	0.571
No/mild dysphagia	99	28.6% (56)	16.3% (43)	-12.3%	0.230
Moderate/severe dysphagia	51	42.1% (19)	15.6% (32)	-26.5%	0.050
COPD no	133	30.9% (68)	13.8% (65)	-17.0%	0.023
COPD yes	17	42.9% (7)	30.0% (10)	-12.9%	0.644
Age < 65	64	25.0% (32)	9.4% (32)	-15.6%	0.184
Age $\geq$ 65	86	37.2% (43)	20.9% (43)	-16.3%	0.153

Abbreviations: PSI, Pneumonia Severity Index; COPD, chronic obstructive pulmonary disease.


Figure 5. Forest plot of subgroup risk differences for the effect of combined intervention on 6-month readmission.

improvement than the control group (0.22 L, 0.15 L, and 0.34 L/s), and superior to the thera-

peutic effects reported for respiratory training alone in previous literature. This incremental benefit may stem from the synergistic mechanism of the two interventions: respiratory training enhances the strength of the diaphragm and intercostal muscles, improves the compliance of the thorax, and increases the endurance of the respiratory muscles, thereby enhancing ventilation reserve at the biomechanical level [19-21]; acupoint application reduces the levels of local

Acupoint application plus respiratory training in post-stroke pneumonia

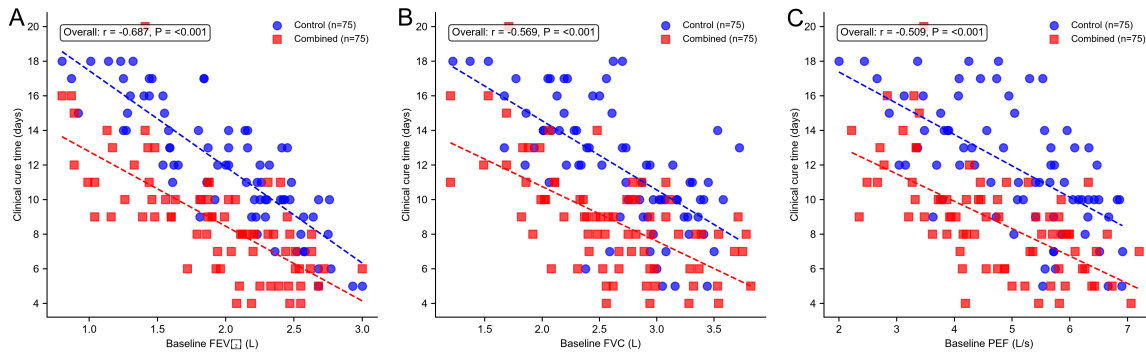


Figure 6. Scatter plots and fitted regression lines of baseline pulmonary function parameters against clinical cure time. A. Baseline FEV_1 . B. Baseline FVC. C. Baseline PEF. Blue and red dashed lines represent fitted regression lines for the control and combined groups, respectively. Abbreviations: FEV_1 , forced expiratory volume in 1 second; FVC, forced vital capacity; PEF, peak expiratory flow.

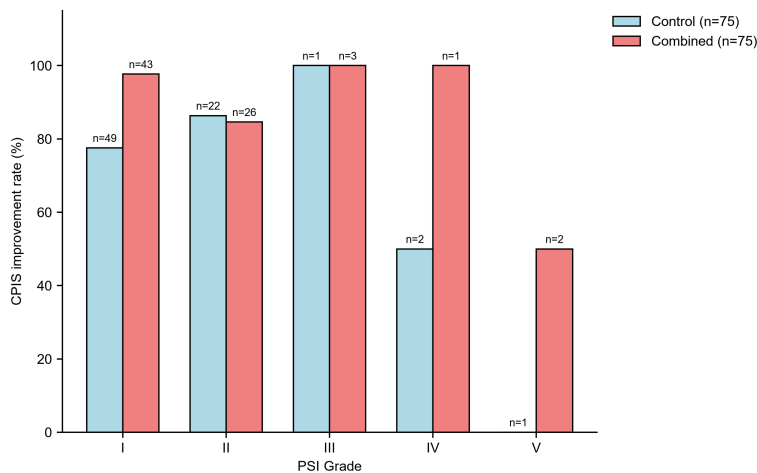


Figure 7. Bar chart of CPIS improvement rate stratified by PSI grade. Abbreviations: CPIS, Clinical Pulmonary Infection Score; PSI, Pneumonia Severity Index.

inflammatory factors (such as $TNF-\alpha$, IL-6, IL-8) in the airway and lung tissue through transdermal absorption of drugs such as white mustard seeds and the acupoint-meridian-organ reflex pathway, alleviates the state of excessive mucus secretion in the airway, and reduces airway resistance [22]. The combination of the two may simultaneously improve airway patency and ventilation efficiency, thereby generating a “1 + 1 > 2” synergistic effect. This study observed that although the between-group difference in the FEV_1/FVC ratio reached statistical significance, the absolute change was extremely small (approximately 0.01-0.02), suggesting that pulmonary function improvement is mainly achieved by increasing lung capacity and flow rate, rather than changing obstructive

ventilation patterns, which is consistent with the pathophysiological characteristics of stroke patients, who mainly have restrictive ventilation disorders [23, 24]. The observed ΔFVC improvement (0.43 L) in our combined group substantially exceeds the pooled estimate from a recent meta-analysis of respiratory training alone in stroke survivors (0.19 L, 95% CI 0.11-0.27 L) [25], and is also numerically superior to the 0.25-0.30 L improvements reported in acupuncture-assisted rehabilitation studies. This incremental benefit suggests that the addition of acupoint application may provide

added value beyond respiratory training alone.

The clinical value of reduced readmission rate. The pneumonia-related readmission rate within 6 months is the core long-term endpoint of this study. In the current medical quality evaluation system, unplanned readmission rate has been regarded as a key indicator for measuring the long-term effect of treatment plans and the efficiency of medical resource utilization [11, 26]. The combined intervention independently reduced 6-month readmission risk (adjusted OR = 0.378, 95% CI 0.163-0.876). Compared with previous literature, the 6-month readmission rate after discharge for stroke patients with pneumonia is generally between 20% and

30% [27, 28]; the 16.0% rate in our combined group falls below this range. However, direct comparisons should be interpreted with caution given substantial heterogeneity across studies in follow-up duration, patient populations, and healthcare systems. For example, a large Japanese nationwide cohort of 305,543 ischemic stroke patients reported 90-day aspiration pneumonia readmission rates of only 1.2-1.5% [29], while a US single-center study reported a 90-day pneumonia readmission rate of 1.8% [30]. These rates are substantially lower than the 16.0-32.0% observed in our cohort, likely reflecting the fact that our study exclusively enrolled patients who developed pneumonia during the index stroke hospitalization - a population at inherently higher risk for respiratory readmission - whereas the Japanese and US cohorts included all stroke survivors regardless of in-hospital pneumonia status. From a mechanistic perspective, the combined intervention may reduce the risk of re-infection through the following pathways: first, the dual improvement of pulmonary function and infection control during hospitalization provides a higher "starting line" for respiratory rehabilitation after discharge; second, the immunomodulatory effect of acupoint application may persist for a period of time after treatment cessation, forming a potential "post-effect" protection; third, the benefits of respiratory training (especially the enhancement of expectoration ability) may continue to play a role in reducing aspiration and promoting airway cleaning after discharge [31, 32]. Subgroup analysis further shows that the benefits of the combined intervention are most obvious in patients with PSI I-II, those without COPD, and those with moderate to severe dysphagia, suggesting that these subgroups may be the priority application populations of the combined intervention. The PSI III-V (only 10 cases) and COPD-positive (17 cases) subgroups, although the rate difference is consistent with the overall trend, have a small sample size, resulting in a wide 95% confidence interval and an insignificant *P* value, and expanding the low sample subgroups is an important direction for future research.

The improvement of hospitalization process indicators and its health economics significance were also evaluated. The clinical recovery time of the combined group was on average

approximately 3.1 days shorter than that of the control group, the total number of hospitalization days was reduced by approximately 2.7 days, and the number of antibiotic use days was reduced by approximately 2.6 days. These differences were statistically and clinically significant. In the current medical environment, each day of shorter hospitalization time means an increase in bed turnover rate and cost savings in medical expenses. According to literature estimates, the average daily hospitalization cost for patients with post-stroke pneumonia is approximately 800-1200 yuan RMB [16, 17]. Based on this calculation, the combined intervention can save approximately 2000-3000 yuan in direct medical costs per patient. In addition, the reduction in the number of antibiotic use days may also bring additional benefits, including reducing the risk of nosocomial *Clostridium difficile* infection, reducing the production of drug-resistant strains, and alleviating antibiotic-related adverse reactions such as intestinal flora disorder [33]. The proportion of the combined group with a decrease in CPIS by ≥ 2 points reached 92.0%, significantly higher than 78.7% of the control group. This objective indicator further corroborates the efficacy of the combined intervention in promoting the clinical relief of pulmonary infections. Stratified analysis showed that in patients with PSI grade I, the improvement rate of CPIS in the combined group was as high as 97.7% (77.6% in the control group), suggesting that patients with mild to moderate pneumonia may be the largest beneficiary group of the combined intervention, while the efficacy for severe pneumonia (PSI III-V grade) still requires larger sample observations. The observed reductions in hospital stay (approximately 2.7 days) and antibiotic duration (approximately 2.6 days) are clinically meaningful and consistent with the broader literature on comprehensive pulmonary rehabilitation in stroke populations, where shorter hospitalization has been associated with reduced healthcare costs and improved bed turnover [16, 17].

Limitations of this study. First, this study uses a single-center retrospective design, which introduces inherent biases. Although the baseline data of the two groups are balanced and comparable in most variables, it is impossible to rule out the influence of treatment selection bias (e.g., the attending physician may be

inclined to give acupoint patches to patients with stronger rehabilitation desires) and unknown confounding factors (such as the patient's economic status, family support level). Second, the specific operational parameters of acupoint application (application duration, drug batch, skin reaction degree, etc.) and the intensity of respiratory training cannot be fully standardized due to the inherent limitations of the retrospective data, although the medical records show that all included patients met the minimum treatment frequency standard. Third, the determination of readmission mainly relies on the hospital information system of this center, which may miss cases where patients were hospitalized for pneumonia in other medical institutions. However, since the patients in both groups come from the same region and the same medical system, the underreporting bias should be non-directional, tending to underestimate the overall readmission rate rather than causing a false positive difference between the groups. Fourth, the total sample size is only 150 cases, especially for the PSI III-V grade (10 cases) and the COPD positive subgroup (17 cases), the number of cases is too small, which not only limits the statistical power of multivariate regression but also makes the results of subgroup analysis should be interpreted as exploratory rather than confirmatory. Fifth, the follow-up period of this study is only 6 months, which cannot assess the long-term impact of the combined intervention on the readmission rate and functional prognosis after 1 year. Finally, as a retrospective study, the results of this study can only be regarded as hypothesis-generating evidence. The true efficacy and safety of acupoint application combined with respiratory training still need to be verified by well-designed multi-center prospective randomized controlled trials.

Conclusion

Acupuncture patch application combined with respiratory training can significantly improve the pulmonary function indicators (FVC, FEV₁, PEF) of stroke patients with pneumonia, shorten the clinical recovery time, hospital stay, and antibiotic use duration, and independently reduce the risk of pneumonia-related readmission within 6 months after discharge. Patients with PSI I-II level, without COPD and moderate

to severe dysphagia may be the priority beneficiaries of the combined intervention. These conclusions need to be further verified by multi-center prospective randomized controlled trials to establish the evidence-based status of this integrated traditional Chinese and Western medicine strategy in post-stroke pulmonary rehabilitation.

Disclosure of conflict of interest

None.

Address correspondence to: Fagen Huang, Intensive Care Medicine Department, Beijing University of Traditional Chinese Medicine Shenzhen Hospital, No. 1 Dayun Road, Longcheng Street, Longgang District, Shenzhen, Guangdong, China. Tel: +86-0755-28338833; E-mail: quex8868@163.com

References

- [1] Dziewas R, Michou E, Trapl-Grundschober M, Lal A, Arsava EM, Bath PM, Clavé P, Glahn J, Hamdy S, Pownall S, Schindler A, Walshe M, Wirth R, Wright D and Verin E. European stroke organisation and european society for swallowing disorders guideline for the diagnosis and treatment of post-stroke dysphagia. *Eur Stroke J* 2021; 6: LXXXIX-CXV.
- [2] de Mello MEL, Andreghetto S, de Aguiar da Costa M, Linden de Rezende V, Gonçalves CL, Giustina AD and Petronilho F. The risk of stroke-related pneumonia: a systematic review of peripheral immunodepression markers. *Expert Rev Respir Med* 2025; 19: 449-459.
- [3] Grossmann I, Rodriguez K, Soni M, Joshi PK, Patel SC, Shreya D, Zamora DI, Patel GS and Sange I. Stroke and Pneumonia: mechanisms, risk factors, management, and prevention. *Cureus* 2021; 13: e19912.
- [4] Darvishi M, Amiri MM, Heidari-Soureshjani S, Sherwin CMT and Mardani-Nafchi H. The association between statins intake and risk of post stroke pneumonia: a systematic review and meta-analysis. *Curr Rev Clin Exp Pharmacol* 2024; 19: 285-293.
- [5] Hsu LC and Fuh JL. Readmission after stroke: recurrence or infection? *J Chin Med Assoc* 2013; 76: 659-660.
- [6] Rabaut J, Thirugnanachandran T, Singhal S, Martin J, Ilevliev S, Ma H and Phan TG. Clinical outcomes and patient safety of nasogastric tube in acute stroke patients. *Dysphagia* 2022; 37: 1732-1739.
- [7] Lee JW, Lee HJ, Jang HJ, Yun Y and Kim DY. Predicting pneumonia algorithm in stroke patients. *Front Neurol* 2025; 16: 1690049.

- [8] Yu Z, Zhou H, Shan B, Fu J, Zhu H, Feng Q, Shen R and Jin X. Clopidogrel increases risk of pneumonia compared with aspirin in acute ischemic minor stroke patients. *J Thromb Thrombolysis* 2021; 52: 301-307.
- [9] Lesch H, Wittayer M, Dias M, Nick A, Ebert A, Eisele P and Alonso A. Clinical features and voxel-based-symptom-lesion mapping of silent aspiration in acute infratentorial stroke. *Dysphagia* 2024; 39: 289-298.
- [10] Akimoto T, Hara M, Ishihara M, Ogawa K and Nakajima H. Post-stroke pneumonia in real-world practice: background, microbiological examination, and treatment. *Neurol Int* 2023; 15: 69-77.
- [11] Sung KL, Kuo MJ, Hsieh CY and Sung SF. High neutrophil-to-lymphocyte ratio predicts one-year risk of pneumonia post-stroke discharge. *Cerebrovasc Dis* 2023; 52: 567-574.
- [12] Wu JJ, Zhang YX, Xu HR, Li YX, Jiang LD, Wang CX and Han M. Effect of acupoint application on T lymphocyte subsets in patients with chronic obstructive pulmonary disease: a meta-analysis. *Medicine (Baltimore)* 2020; 99: e19537.
- [13] Lu M, Xue J, Wang Y, Chen D, Cao Y, Zhong C and Zhang X. The joint effect of renal function status and coagulation biomarkers on in-hospital outcomes in acute ischemic stroke patients with intravenous thrombolysis. *Immun Inflamm Dis* 2024; 12: e70099.
- [14] Huang Z, Zhu X, Xu X, Wang Y, Zhu Y, Chen D, Cao Y and Zhang X. The joint effects of inflammation and renal function status on in-hospital outcomes in patients with acute ischemic stroke treated with intravenous thrombolysis. *BMC Neurol* 2024; 24: 493.
- [15] Li C, Ma M, Dong S, Hong Y, Bao J, Zhang Y, Gao L, Cui C, Guo J and He L. Statin treatment in the acute phase and the risk of post-stroke pneumonia: a retrospective cohort study. *Front Neurol* 2021; 12: 635079.
- [16] Tu X, Shi C, Jiang J, Lu X, Fan L, Shi X, Li Q and Wang L. Association between stress hyperglycemia and pneumonia in patients with stroke: a systematic review and meta-analysis. *BMC Pulm Med* 2025; 25: 421.
- [17] Shan W, Xu M, Gong X, Xie Y, Zhang X, Yan E, Zhu H, Lei Y and Xu L. General anesthesia vs. non-general anesthesia for elderly stroke patients treated with mechanical thrombectomy. *Front Neurol* 2026; 17: 1753649.
- [18] Fine MJ, Auble TE, Yealy DM, Hanusa BH, Weissfeld LA, Singer DE, Coley CM, Marrie TJ and Kapoor WN. A prediction rule to identify low-risk patients with community-acquired pneumonia. *N Engl J Med* 1997; 336: 243-250.
- [19] Kovács A, Szabó PT, Óváry C, Molnár A, Veresné Bálint M, Béres-Molnár KA and Folyovich A. Medical nutrition therapy of stroke patients with dysphagia - 2021. *Orv Hetil* 2021; 162: 1601-1609.
- [20] Boudiba Y, Gens R, Ourtani A, De Backer G, Guldolf K, Vandervorst F and De Raedt S. Post-stroke delirium is a predictor of prolonged hospital stay and poor functional outcome at 3 months. *Front Stroke* 2025; 4: 1719748.
- [21] Phan TG, Beare R, Bath PM, Ievlieva S, Ho S, Ly J, Thrift AG, Srikanth VK and Ma H; VISTA-Acute Collaborators. Effect of alteplase, benzodiazepines and beta-blocker on post-stroke pneumonia: exploration of VISTA-Acute. *PLoS One* 2023; 18: e0281617.
- [22] Somogyi P, Babik B, Farkas E and Peták F. Lung function impairment following cerebral ischemic stroke: pathophysiology, mechanisms, and clinical challenges. *Respir Physiol Neurobiol* 2026; 342: 104567.
- [23] Arai S, Hoshino T, Mizuno T, Ishizuka K, Hosoya M, Takahashi S, Wako S, Toi S, Kitagawa K and Todo K. Association between serum interleukin-6 levels and long-term outcomes after ischemic stroke: a prospective cohort study. *J Atheroscler Thromb* 2026; 33: 195-203.
- [24] Gens R, Ourtani A, De Vos A, De Keyser J and De Raedt S. Usefulness of the neutrophil-to-lymphocyte ratio as a predictor of pneumonia and urinary tract infection within the first week after acute ischemic stroke. *Front Neurol* 2021; 12: 671739.
- [25] Wu M, Mo MY, Huang XD and Wei J. Implications for respiratory muscle training in patients with stroke-associated pneumonia: a meta-analysis. *Disabil Rehabil* 2024; 46: 5791-5797.
- [26] Li X, Yu J and Shu C. Bibliometric analysis of global research trends on post-stroke pneumonia: current development status and research Frontiers. *Front Public Health* 2022; 10: 950859.
- [27] Weng Y and Shen T. The impact of post-stroke pneumonia on survival and functional outcomes: a systematic review and meta-analysis. *Pak J Med Sci* 2025; 41: 3001-3012.
- [28] Sadiq AO, Awotidebe AW, Saeys W, Truijen S, Wong TWL, Ng SSM and Abdullahi A. Prevalence, associated factors and predictors of post stroke pneumonia in a Nigerian population: a retrospective study. *J Stroke Cerebrovasc Dis* 2023; 32: 107404.
- [29] Sato S, Yamana H, Kumazawa R, Watanabe H, Fujita A, Matsui H, Fushimi K and Yasunaga H. Cilostazol versus aspirin or clopidogrel for reducing post-stroke aspiration pneumonia: a nationwide retrospective cohort study. *Cerebrovasc Dis* 2024; 53: 152-159.

Acupoint application plus respiratory training in post-stroke pneumonia

- [30] Bouddhara T, Persondek L, Ablah E, Okut H, Lu L and Walker J. Post-stroke pneumonia: factors associated with readmission within 90 days of stroke discharge. *J Stroke Cerebrovasc Dis* 2023; 32: 107276.
- [31] Gao J, Chen X, Huang Q, Gu M, Hong Y and Xu G. Stress hyperglycemia is associated with unfavorable outcomes after mechanical thrombectomy in patients with acute ischemic stroke. *Brain Sci* 2025; 15: 360.
- [32] Li J, Li Q and Zhou L. Analyzing the nonlinear association between length of hospital stay and post-stroke pneumonia risk a secondary analysis of the Henan Province stroke registry. *Front Neurol* 2026; 17: 1711762.
- [33] Lee CC, Su SY and Sung SF. Machine learning-based survival analysis approaches for predicting the risk of pneumonia post-stroke discharge. *Int J Med Inform* 2024; 186: 105422.