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The Application Value of Chest CT Combined with Serum Vanin-1 and SPP1 in Diagnosing the Severity of Chronic Obstructive Pulmonary Disease

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Abstract: *Objective:* To investigate the quantitative assessment efficacy of chest CT combined with serum Vanin-1 and SPP1 in determining the progression stage of chronic obstructive pulmonary disease (COPD). *Methods:* A total of 100 COPD subjects from our hospital from January 2020 to December 2023 were included and randomly divided into a healthy control group and an experimental group (50 cases each). The healthy control group underwent slow vital capacity measurement using a spirometer, while the experimental group underwent high-resolution thin-slice CT scans and serum Vanin-1 and SPP1 concentration measurements. Pulmonary function parameters, symptom burden, biomarker concentrations, and imaging characteristics were compared between the two groups. *Results:* The FEV1/FVC ratio in the experimental group (58.3 ± 7.2) was lower than that in the healthy control group (92.1 ± 4.8); the total CAT score (22.4 ± 3.5) was higher than that in the healthy control group (3.1 ± 1.2); both Vanin-1 (18.7 ± 2.3 μg/L) and SPP1 (25.6 ± 4.1 μg/L) levels were higher than those in the healthy control group; LAA%-950 (38.7 ± 6.2%) and WA% (68.5 ± 5.3%) were significantly higher than those in the healthy control group (all $p < 0.001$). *Conclusion:* Chest CT combined with serum Vanin-1 and SPP1 can accurately quantify the pathological progression of COPD, providing a dual basis for clinical staging and individualized intervention.

Keywords: Chronic obstructive pulmonary disease; Chest CT; Vanin-1; SPP1; Disease assessment

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1. Introduction

COPD is one of the common chronic respiratory diseases, characterized primarily by progressively worsening lung damage and irreversible airway obstruction. When the disease progresses to a severe stage, it often presents with complications such as respiratory failure and coronary pulmonale, thereby affecting the body's ventilation and gas exchange functions, leading to substantive lung lesions. It may also trigger acute infections, potentially causing Multiple Organ Dysfunction Syndrome (MODS) in patients. Its main symptoms include dyspnea, asthma, chest tightness, cough with expectoration, etc. The classification of lung function is of great significance in improving

patient prognosis [1]. However, traditional pulmonary function tests are complex and imprecise [2]. In recent years, the application of various imaging techniques and serum biochemical markers has enabled more accurate diagnosis and staging of COPD, offering the advantages of simplicity and reliability. This study aims to analyze the value of CT imaging features, as well as Vanin-1 and SPP1, in the staging of COPD and to explore the optimal method for observing pathological progression.

2. Materials and methods

2.1. Clinical data

For convenience, a total of 100 patients who underwent treatment in the respiratory medicine department of our hospital and received chest examinations from January 2020 to December 2023 were selected as the subjects of this study, including 58 males and 42 females. These 100 patients were divided into a control group (healthy individuals) and an observation group (COPD patients), with 50 cases in each group, using a simple randomization method. The average age of patients in the control group was 40.2 ± 0.5 years, with an age range of 25 to 55 years. The average age of patients in the observation group was 62.8 ± 0.5 years, with an age range of 45 to 75 years. Comparison revealed no significant differences in the basic data between the two groups, i.e., $p > 0.05$, indicating comparability. The inclusion criteria mainly included the following: meeting the relevant diagnostic criteria for COPD (GOLD). Exclusion criteria: concurrent asthma and bronchiectasis or recent infection; patients signed written informed consent forms.

2.2. Detection methods

2.2.1. Healthy control group

All healthy individuals underwent routine pulmonary function tests using a German Jaeger MasterScreen pulmonary function machine, scanned using the slow vital capacity method. Patients were instructed to refrain from smoking for 24 hours prior to the examination and to avoid physical exercise. Attention was paid to instrument settings, and patients were instructed to follow breathing instructions. During the examination, the ATS/ERS guidelines were strictly followed to avoid technical errors and ensure the authenticity and reliability of the data.

2.2.2. Experimental group

All COPD patients should undergo chest CT combined with serological testing. Scanning should be performed using a Siemens SOMATOM Force dual-source CT scanner, employing a high-resolution thin-slice scanning approach. Patients should fast for 12 hours and have 5 mL of venous blood drawn, which was then separated to obtain serum. Bronchodilators should be discontinued 48 hours prior to the examination. Patients should be instructed to remain still with steady breathing and remove any metallic foreign objects to avoid artifacts that could interfere with image quality. The scanning range should cover from the thoracic inlet to the lower edge of the diaphragm, with the patient in a supine position and arms raised. The patient should hold their breath to ensure full coverage of the lung fields. After performing a routine non-contrast scan, targeted scan reconstruction should be conducted. The equipment parameters should be set as follows: tube voltage at 120 kV, tube current at 200 mAs, collimator width at 0.6 mm, pitch at 1.2, slice thickness at 1.0 mm, reconstruction interval at 0.5 mm, and convolution kernel I70f. Iterative reconstruction techniques should be used for scanning, with a window width of 1500 HU and a window level of -600 HU, to obtain transverse and coronal images. Serum concentrations of

Vanin-1 and SPP1 should be measured using the ELISA method, following the instructions provided in the reagent kit strictly.

2.3. Observation indicators

The first part consists of pulmonary ventilation function indicators: FEV1/FVC, FEV1%pred, FVC, DLCO, and RV/TLC indices should be measured using a pulmonary function tester, with normal ranges defined according to the standards established by the ATS/ERS. The second part comprises clinical symptom indices: including the CAT (0–40 points), mMRC (0–4 grades), SGRQ questionnaire, 6-minute walk test, and the total score based on the annual frequency of AECOPD occurrences. Section 3 analyzes serum protein levels, encompassing Vanin-1 and SPP1 levels, as well as enzyme-linked immunosorbent assay (ELISA) and chemiluminescent immunoassay (CLIA) standard methods for C-reactive protein (CRP), interleukin (IL)-6, and tumor necrosis factor (TNF)-α. The final section focuses on understanding anatomical abnormalities, including the evaluation of CT emphysema proportion (LAA%-950), bronchial wall area (BW) percentage (WA%), mean perimembranous density (mPDA), pulmonary artery (PA)/aorta (Ao) ratio, and wall thickness (WT).

2.4. Statistical analysis

Data calculations were performed using SPSS 25.0 software. Continuous variables were described using mean ± standard deviation ($\overline{x} \pm s$), with independent sample *t*-tests employed for inter-group difference analysis and paired *t*-tests for intra-group dynamic changes. Discrete variables were expressed as frequencies and percentages, with chi-square tests used for inter-group comparisons. A *p*-value of less than 0.05 was considered statistically significant.

3. Results

3.1. Comparison of pulmonary function parameters between two groups of subjects

Statistically significant differences were observed between the experimental group and the healthy control group in terms of FEV1/FVC, FEV1%pred, FVC, DLCO% pred, and RV/TLC% ($p < 0.001$). Specific values are presented in **Table 1**.

Table 1. Comparison of pulmonary function parameters between two groups ($\overline{x} \pm s$)

Parameter	Healthy control group (n = 50)	Experimental group (n = 50)	*t*-value	*p*-value
FEV_1/FVC (%)	92.1 ± 4.8	58.3 ± 7.2	32.17	< 0.001
FEV_1 (% predicted)	98.7 ± 3.2	52.4 ± 8.6	41.85	< 0.001
FVC (L)	3.8 ± 0.6	2.9 ± 0.5	15.22	< 0.001
DL_{CO} (% predicted)	95.3 ± 5.1	68.2 ± 9.4	24.36	< 0.001
RV/TLC (%)	35.2 ± 4.3	62.7 ± 7.8	28.94	< 0.001

3.2. Comparison of symptom scores between the two groups of participants

Statistically significant differences were observed between the two groups in terms of the total CAT score, mMRC grade, total SGRQ score, 6MWD, and the number of acute exacerbations ($p < 0.001$). Detailed data are presented in **Table 2**.

Table 2. Comparison of symptom scores between the two groups ($\overline{x}$ ± s)

Assessment scale	Healthy control group (n = 50)	Experimental group (n = 50)	*t*-value	*p*-value
CAT total score	3.1 ± 1.2	22.4 ± 3.5	45.28	< 0.001
mMRC grade	0.4 ± 0.2	2.8 ± 0.7	38.16	< 0.001
SGRQ total score	15.3 ± 3.7	62.8 ± 8.9	42.77	< 0.001
6MWD (m)	580.2 ± 45.3	320.5 ± 62.7	28.44	< 0.001
Exacerbations (times/year)	0.1 ± 0.3	2.3 ± 0.9	19.82	< 0.001

3.3. Comparison of serum marker levels between the two groups of participants

Statistically significant differences were found in the concentrations of Vanin-1, SPP1, CRP, IL-6, and TNF-α between the experimental group and the healthy control group ($p < 0.001$). Specific results are shown in **Table 3**.

Table 3. Comparison of serum marker levels between the two groups ($\overline{x}$ ± s, μg/L)

Biomarker	Healthy control group (n = 50)	Experimental group (n = 50)	*t*-value	*p*-value
Vanin-1 (ng/mL)	8.2 ± 1.5	18.7 ± 2.3	29.35	< 0.001
SPP1 (ng/mL)	9.3 ± 2.4	25.6 ± 4.1	27.88	< 0.001
CRP (mg/L)	1.8 ± 0.7	8.5 ± 2.3	22.14	< 0.001
IL-6 (pg/mL)	3.2 ± 1.1	15.7 ± 3.8	25.67	< 0.001
TNF-α (pg/mL)	4.5 ± 1.3	12.9 ± 2.7	23.41	< 0.001

3.4. Comparison of imaging parameters between the two groups of participants

Statistically significant differences were observed between the two groups in terms of LAA%-950, WA% (2 mm bronchi), mPDA, PA/Ao, and bronchial wall thickness ($p < 0.001$). Detailed data are provided in **Table 4**.

Table 4. Comparison of CT Imaging parameters between the two groups ($\overline{x}$ ± s)

Imaging index	Healthy control group (n = 50)	Experimental group (n = 50)	*t*-value	*p*-value
LAA%-950 (%)	5.3 ± 1.8	38.7 ± 6.2	42.33	< 0.001
WA% (2 mm Bronchi)	52.1 ± 4.7	68.5 ± 5.3	21.56	< 0.001
mPDA (mm)	1.8 ± 0.3	2.7 ± 0.5	18.24	< 0.001
Pulmonary artery diameter (PA/Ao)	0.9 ± 0.1	1.3 ± 0.2	20.87	< 0.001
Bronchial wall thickness (mm)	1.2 ± 0.2	1.9 ± 0.4	19.63	< 0.001

4. Discussion

In summary, the results of this study indicate that chest CT and serum Vanin-1 and SPP1 levels hold significant clinical value for the quantitative analysis of COPD severity. Compared to healthy individuals, COPD patients in this study exhibited a significant decrease in FEV1/FVC (58.3 ± 7.2)% and FEV1% (52.4 ± 8.6)%, along with an increase in RV/TLC (62.7 ± 7.8)%, indicating varying degrees of ventilatory dysfunction and gas trapping in COPD patients [3]. The study group showed higher total CAT scores (22.4 ± 3.5), mMRC scores (2.8 ± 0.7), and

total SGRQ scores (62.8 ± 8.9) compared to the control group, along with a longer 6-minute walk distance (320.5 ± 62.7) m, an increased frequency of acute exacerbations, suggesting a marked decline in exercise capacity and quality of life as the disease progresses. The levels of Vanin-1 (18.7 ± 2.3) μg/L and SPP1 (25.6 ± 4.1) μg/L in the study group were more than twice as high as those in the control group, while elevated CRP and IL-6 levels indicated the initiation of oxidative stress responses and extracellular matrix resorption processes. Additionally, significant deviations from normal ranges in LAA%-950 (38.7 ± 6.2)%, WA% (68.5 ± 5.3)%, and PA/Ao (1.3 ± 0.2) indicated pronounced airway collapse and pulmonary vascular remodeling. These indicators are consistent with the GOLD classification of COPD pathological stages [4]. Furthermore, Liang Feng's research suggests that chest CT indicators are also effective in evaluating pulmonary hypertension (PH), further demonstrating that combining imaging and hematological indicators can better reflect disease changes and compensate for the limitations of simple pulmonary function tests [5].

Mechanistically, Vanin-1 is a protein whose expression is readily upregulated in response to oxidative stress, and its levels increase with the aggravation of lung injury. SPP1 plays a pivotal role in this process by mediating macrophage polarization, thereby promoting the formation of airway scars. Both proteins contribute to the cascade effect of inflammatory responses. In this experiment, the changing trends of the inflammatory markers IL-6 and TNF-α closely resembled those of Vanin-1 and SPP1, aligning with the viewpoint proposed by Yang Qian et al. that serum biomarkers hold significant importance in judging infections in patients with COPD complicated by infections [6]. This suggests that, in addition to being used for monitoring basic disease status, the combined model can also be employed for predicting other diseases. In practical applications, this approach shifts the therapeutic goal from "symptom relief" to "quantitative evaluation of the disease process". Specifically, CT indicators can provide qualitative and objective descriptions of the extent of tissue and organ lesions, while hematological indicators can offer quantitative information on changes in cytokine levels. The combination of these two types of indicators makes it possible to promptly and effectively implement targeted treatment measures for patients. Moreover, as Chen Yahong pointed out, given the complexity of COPD comorbidities, a comprehensive evaluation is necessary. The scoring model proposed in this paper reflects both the presence of PA/Ao abnormalities and elevated SPP1 levels in patients, guiding clinical interventions tailored to individual patients. However, this study has limitations, including a single-center sample size and a lack of subdivision of COPD subtypes. Research by Huang Juan et al. suggests that complications such as fungal infections may interfere with the specificity of biomarkers [7]. Future studies should expand the sample size for validation and explore the warning value of dynamic monitoring of Vanin-1/SPP1 during acute exacerbations.

In summary, in the future, we need to develop a three-dimensional evaluation system that integrates "imaging-serology-function", such as conducting follow-up observations by combining changes in lung function and utilizing AI technology to analyze CT images, extracting subtle feature information and corroborating it with serological indicators. Additionally, we need to consider how to apply these examination methods to clinical diagnostic work. Meanwhile, it is also recommended to include populations with comorbid cardiovascular and cerebrovascular diseases, as well as metabolic diseases, in multicenter studies, and explore whether this scoring system is also applicable to such populations, truly achieving the goal of "panoramic diagnosis of COPD with comorbidities" proposed by Chen Yahong, and realizing a new leap from disease treatment to health management.

5. Conclusion

In conclusion, the combination of chest CT with serum Vanin-1 and SPP1 can objectively evaluate respiratory dysfunction, parenchymal lung lesions, and cytokine release in COPD patients from both qualitative and quantitative perspectives, providing more comprehensive information for disease diagnosis. This aids in assessing the severity of the disease and implementing targeted treatment measures, thereby facilitating the development of a reasonable treatment plan. In future research, further refinement of relevant indicators and their combination with other detection methods will lead to greater breakthroughs. It will become an important means of comprehensive management for COPD, thereby improving patients' long-term prognosis and quality of life.

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Disclosure statement

The authors declare no conflict of interest.

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