Brief Report

Does pulmonary embolism guideline increase the pulmonary vascular obstruction index and help to elucidate the severity of pulmonary embolism?

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Abstract: According to Chinese Thoracic Society (CTS) guidelines, patients with pulmonary embolism (PE) can be stratified into low-risk, intermediate-low, intermediate-high, and high-risk groups based on the severity and comorbidity assessment. For low-risk PE patients, anticoagulant therapy can be given in outpatient department. Patients at high risk for PE may require thrombolytic therapy; however, this risk stratification is not included in comparing the pulmonary vascular obstruction index (PVOI) assessment. In practice, this severity and comorbidity assessment often leads people to believe that PE severity is positively correlated with PVOI assessment, i.e., the larger the thrombus, the higher the risk stratification, and the smaller the thrombus, the lower the risk stratification. Herein, we investigated the relationship between PVOI and risk stratification and prognosis in PE patients. We found that although some patients had a greater PVOI, they were low-risk patients according to the PE severity. Moreover, even though some patients had small PVOI, they were intermediate-risk and high-risk patients, and their PVOI did not correlate with the severity of PE. Therefore, we recommend that the PE guidelines add a classification of the degree of thrombus occlusion to the risk group, as this could reduce misconceptions about the severity and comorbidity assessment of PE.

Keywords: Pulmonary embolism (PE); pulmonary vascular obstruction index (PVOI); risk stratification

Submitted Sep 07, 2023. Accepted for publication Mar 22, 2024. Published online May 21, 2024.
doi: 10.21037/jtd-23-1419
View this article at: https://dx.doi.org/10.21037/jtd-23-1419

Introduction

Chinese Thoracic Society (CTS) guidelines for the diagnosis and management of acute pulmonary embolism (APE) [2018] highly recommend that risk stratification of hemodynamics, markers of myocardial injury, and markers of right ventricular dysfunction should be performed using echocardiography or computed tomography after pulmonary embolism (PE) is confirmed, and given appropriate treatment (1). For low-risk PE patients, anticoagulant therapy can be given in outpatient department (2). Patients at high risk for PE may require thrombolytic therapy (3); therefore, risk assessment of PE is significant to treatment.

However, this risk stratification is not included in comparing the degree of pulmonary thrombosis. Previous studies (4,5) have shown that the degree of thrombosis is related to arterial blood gas, D-dimer, B-type natriuretic peptide (BNP), etc., while the correlation between the degree of thrombosis and the risk stratification of PE is rarely studied. Also, we observed that this severity and comorbidity assessment method often leads people to believe that PE severity positively correlates with pulmonary vascular obstruction index (PVOI).

This study investigated the relationship between PVOI and risk stratification and prognosis in PE patients. We

aimed to explore the correlation between PVOI and severity and comorbidity assessment and reduce the general misunderstanding of PE.

Methods

Patients

A total of 261 PE patients, including 123 males and 138 females aged 22–91 years, diagnosed by computed tomography pulmonary angiography (CTPA) in the Department of Respiratory and Critical Care Medicine of Shanghai Sixth People's Hospital between January 2013 and August 2022 were enrolled in this study. The patients were divided into high-risk patients (12 cases), medium-high-risk patients (114 cases), medium-low-risk patients (54 cases), and low-risk patients (81 cases). The inclusion criteria used in the present investigation were based on the diagnostic criteria of "Guidelines for the diagnosis, treatment, and prevention of pulmonary thromboembolism" published by the CTS in 2018. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Ethics Committee of Shanghai Sixth People's Hospital Affiliated to Jiao Tong University School of Medicine. (No. DY-KY-2019012) and individual consent for this retrospective analysis was waived.

PVOI

According to the Qanadli PVOI, the percentage of vascular obstruction was calculated by dividing the patient score by the maximal total score and multiplying the result by 100[4]. Therefore, the CT obstruction index was expressed as $\sum(n \times d)/40 \times 100\%$, where n is the value of the proximal thrombus in the pulmonary arterial tree equal to the number of segmental branches arising distally (minimum, 1; maximum, 20), and d is the degree of obstruction (minimum, 0; maximum, 2).

Statistical analysis

SPSS17.0 statistical software was used for statistical analysis. Proportions and frequency distributions were calculated for categorical variables and means ± standard deviation for continuous variables. Student's *t*-test and Mann-Whitney test were used to compare continuous and nonparametric variables, respectively. Spearman's correlation coefficient was used to analyze associations between PVOI and the risk degree and mortality of PE. In all instances, a P value <0.05 was considered statistically significant.

Results

Our results demonstrated that the basic diseases of PE in low-risk, intermediate-low-risk, and high-risk groups were significantly different (P<0.05). Three cases in the low-risk patients had single pulmonary segment thrombosis, and others had multiple pulmonary thrombosis, while 20 cases in the intermediate-high-risk patients had single or two pulmonary segments arterial thrombosis; therefore, PVOI was not statistically significant. The results are shown in *Table 1*.

Further analysis showed that in some patients with chronic heart failure, chronic pulmonary disease, or cancer, cardiac biological markers, including markers of myocardial injury [troponin I (TNI)] and markers of right ventricular dysfunction [BNP or N-terminal BNP (NT-proBNP)] were abnormal before confirmed PE. However, when PE was present, markers of myocardial injury and markers of right ventricular dysfunction were higher than normal, resulting in risk stratification into intermediate-risk and high-risk PE. For this part of patients, we believe that the risk assessment of PE should be evaluated by comparing their underlying merit changes.

In addition, when acute PE occurred, troponin T (TNT) or TNI, BNP were increased. Nevertheless, with the extension of treatment time, the body gradually compensates, TNT or TNI, BNP, and cardiac dilation index declined to normal, which may also affect the risk stratification of some patients. However, there was no difference in visit time in this dataset.

Spearman correlation analysis showed that PVOI was not correlated with risk stratification (Rs =0.112, P=0.07); PVOI was correlated with mortality (Rs =0.272, P<0.001); and mortality was correlated with risk stratification (Rs =0.317, P<0.001). Chronic heart failure and chronic pulmonary disease were associated with stratified risk of PE (Rs =0.693, P<0.001).

Excluding the high-risk group, we compared the low-risk group with the intermediate-low-risk group and the intermediate-high-risk group, and Spearman correlation analysis showed that PVOI was not correlated with risk stratification (Rs =0.029, P=0.60); PVOI was correlated with mortality (Rs =0.133, P=0.03); and mortality was not correlated with risk stratification (Rs =0.078, P=0.20).

Table 1 Comparison of the risk factors

General information	Low-risk patients (n=81)	Intermediate-low-risk patients (n=54)	Intermediate-high-risk patients (n=114)	High-risk patients (n=12)	P value
Male/female	38/43	24/30	55/59	6/6	0.70
Age (years)	61.75±14.55	68.72±13.86	66.83±16.12	65.25±8.6	0.03
Duration of untreated illness (days)	6.53±5.16	7.43±7.7	7.33±7.01	5.42±4.144	0.70
Malignant tumor	10	8	4	7	<0.001
Chronic pulmonary failure	11	8	73	5	<0.001
Chronic heart failure	0	0	37	6	<0.001
30-day mortality	1	2	10	10	<0.001
cTNI (ng/mL)	0.017±0.0127	0.231±0.469	0.734±0.35	0.865±0.632	0.30
BNP (pg/mL)	111.13±121.66	633.53±680.9	1,769.18±180.17	2,212.54±1.67	<0.001
PaO_2 (mmHg)	78.61±14.51	80.29±21.01	78.48±17.61	65.45±9.87	0.06
$PaCO_2$ (mmHg)	37.95±6.28	38.39±6.94	38.29±8.92	36.2±6.0	0.80
D-dimer (mg/L)	7.08±6.51	10.95±10.02	6.45±6.18	6.127±4.225	0.002
PVOI (%)	26.60±15.89	29.61±17.20	26.69±17.97	77.08±16.71	<0.001

Data are expressed as case number or mean ± standard deviation. Basic diseases, cTNI and Pro-BNP were statistically significant between low-risk, intermediate-risk and high-risk groups (P<0.05). PVOI, PaO_2, $PaCO_2$ and D-dimer were not significantly different between low-risk and intermediate-risk groups (P>0.05). PVOI, PaO_2, $PaCO_2$ and D-dimer were statistically significant between low-risk, intermediate-risk and high-risk groups (P<0.05). cTNI, cardiac troponin I; BNP, B-type natriuretic peptide; PaO_2, oxygen partial pressure; $PaCO_2$, partial pressure of carbon dioxide; PVOI, pulmonary vascular obstruction index.

Discussion

In the past, the diagnosis of PE by CTPA was mainly qualitative. In recent years, with the proposal of PVOI, more and more studies (6-8) have confirmed that PVOI can be used for risk stratification of PE. Qanadli *et al.* (9) obtained the degree of pulmonary thrombosis by setting the percentage of pulmonary vascular blockage. Since then, PVOI has been widely used in clinical practice. While it was found that PVOI was correlated with D-dimer, arterial blood gas, BNP, and TNI, the correlation between PVOI and the risk of PE has been less studied.

Our results showed that chronic heart failure and chronic pulmonary disease were increased in patients with intermediate-risk and high-risk PE compared with those with low-risk PE, which is one of the important reasons leading to the diagnosis of intermediate-risk and high-risk PE. Among the low-risk PE patients, 19 patients had multiple thrombosis in the main and branches of the left and right pulmonary arteries. These patients had good right ventricular function and pulmonary function and no chronic heart failure or chronic pulmonary disease. Therefore, echocardiography and cardiac TNI or TNT were negative, indicating the low-risk group. Among the intermediate-risk and high-risk PE patients, 20 patients had single- or two-segment pulmonary artery thrombosis due to a history of chronic heart failure, chronic pulmonary disease, or cancer. Patients who had chronic hypoxemia and poor decompensation of right ventricular dysfunction, pulmonary dysfunction, echocardiography, and positive cardiac TNI or TNT were categorized as intermediate-high-risk groups. We compared the correlation analysis of chronic heart failure, chronic pulmonary disease or cancer, and risk stratification, finding that chronic heart failure, chronic pulmonary disease, or cancer were associated with the risk stratification of PE.

Wu *et al.* (10) reported that among patients with pulmonary artery obstruction <60%, the mortality rate was 1.9%, while among patients with pulmonary artery obstruction >60%, the mortality rate was 83%, suggesting that PVOI, as an indicator for evaluating the severity of PE, still has predictive value for the prognosis of patients.

Our study showed that PVOI was correlated with mortality (Rs value was 0.272, P<0.001). The results of this study are consistent with those above.

The present study has some limitations. This was a study with a retrospective design conducted at a single center. The sample was not representative. Also, only 12 high-risk patients were enrolled, and long-term follow-up data were not included. The limited sample size of the high-risk group may not fully reflect the overall characteristics, thus generating sampling errors. Therefore, given the preliminary findings in this study, it would be beneficial to repeat this research using a larger prospective cohort of patients from multiple institutions, including abundant medical history and long-term follow-up data.

Conclusions

PVOI was not correlated with clinical severity of PE, while PVOI was correlated with mortality. Therefore, we recommend that the PE guidelines add a classification of the degree of thrombus occlusion to the risk group, as this may reduce misconceptions about the severity and comorbidity assessment of PE.

Acknowledgments

Funding: This study was supported by the Shanghai Pudong New Area Science and Economic Commission Minsheng Technology Special Fund (grant No. PKJ2019-Y01).

Footnote

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1419/prf

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1419/coif). Both authors report Shanghai Pudong New Area Science and Economic Commission Minsheng Technology Special Funding for this study. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Ethics Committee of Shanghai Sixth People's Hospital Affiliated to Jiao Tong University School of Medicine (No. DY-KY-2019012) and individual consent for this retrospective analysis was waived.

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Cite this article as: Liu Y, Yang D. Does pulmonary embolism guideline increase the pulmonary vascular obstruction index and help to elucidate the severity of pulmonary embolism? J Thorac Dis 2024;16(5):3361-3365. doi: 10.21037/jtd-23-1419