Scholars Journal of Applied Medical Sciences
Abbreviated Key Title: Sch J App Med Sci
ISSN 2347-954X (Print) | ISSN 2320-6691 (Online)
Journal homepage: https://saspublishers.com

OPEN ACCESS

Radiodiagnosis

Assessment of Utility of Computed Tomography Pulmonary Angiography in Pulmonary Embolism

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DOI: 10.36347/sjams.2023.v11i03.002 | **Received:** 17.01.2023 | **Accepted:** 21.02.2023 | **Published:** 03.03.2023

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Abstract **Original Research Article**

***Background*:** Among all the available diagnostic tools, computed tomography (CT) is the preferred diagnostic tool for clinically suspected pulmonary embolism (PE) cases. Further, with the development of multi–detector row CT (MDCT) technology, previous limitations of CT have been overcome effectively. For patients with clinical suspicion of PE, MDCT pulmonary angiography has become the first line of modality for the diagnosis. ***Aims and Objectives*:** To evaluate various common observations of CT pulmonary angiography (CTPA) in suspected cases of PE that could accurately determine the choice of management. ***Materials and Methods*:** Fifty patients with clinically suspected PE referred to the department of Radiodiagnosis for CTPA from various departments were studied in the cross-sectional study. CT images were obtained with a SIEMENS 64-slice multi-detector CT scanner (somatom definition AS). Images were reconstructed into 3D, axial, coronal, sagittal maximum intensity projection sections, and volume rendering techniques. The axial as well as reformatted coronal and sagittal images were evaluated. ***Results*:** The incidence of PE was 52%. The incidence of PE was highest in patients older than 60 years (30.8%) and males (30.3%; p=0.662). The most common symptoms evoking a suspicion of pulmonary embolism were dyspnea (69.2%), followed by chest pain (15.4%), cough (11.5%), and hemoptysis (3.8%). Out of 26 patients who had PE, 61.5% had right ventricular enlargement. DVT (23.1%) was the most common past history. The majority of the patients had thrombus in the right main pulmonary artery (21.1 %), followed by the left main pulmonary artery (19.3 %). ***Conclusion*:** In clinically suspected cases of PE, MDCT pulmonary angiography was a useful diagnostic tool. CTPA is the modality of choice for its rapid, minimally invasive, and well-tolerated nature.

Keywords: Computed tomography, pulmonary thromboembolism, multi-detector computed tomography, CTPA.

INTRODUCTION

Pulmonary embolism (PE) is one of the common diseases with high morbidity and mortality. (Lei M 2021) It is the third most common cause of death after myocardial infarction and stroke. Because of its nonspecific clinical presentation, the condition is still difficult to diagnose clinically and is a major public health problem (Goldhaber SZ 2004).

Clinical history and physical examination were the primary diagnostic tools in the suspected cases. Even after combining the findings of electrocardiogram, D dimer levels, arterial blood gas analysis, and chest radiographs, the results were still inaccurate in confirming the PE. The results were far low in accuracy till the advent of accurate diagnostic tests (Lei M 2021).

Conventional pulmonary angiography (Stein PD 1992), introduced in the 1960s, was considered the gold standard diagnostic tool for pulmonary embolism. The main disadvantage of conventional pulmonary angiography is it is an invasive test though the complications reported were very few with the technique. It is seldom done nowadays and is replaced by more accurate and non-invasive techniques (Lei M 2021). Another method that was introduced in the 1960s itself was lung perfusion scintigraphy. It was used extensively as a diagnostic tool for PE as it is a non-invasive test. High sensitivity and high negative predictive value were the advantages. Unfortunately, the technique suffers from many indeterminate studies in which the diagnosis of PE cannot be reliably confirmed or excluded (Bhgwat KA 2018).

Since the 1990s, the diagnostic strategy for pulmonary embolism was changed. Computed tomography (CT) and pulmonary angiography (CTPA) has become the principal diagnostic tool worldwide for PE diagnosis. The earlier techniques are only used nowadays if CTPA is contraindicated, inconclusive, or unavailable (Doğan H 2015). The most important advantages of CTPA over other diagnostic tools include the visualization of the thrombus directly, both mediastinal and parenchymal structures can be evaluated, and diagnoses of other clinical conditions can be made (Moore AJE 2018).

Along with direct visualization of the thrombus, evaluation of cardiac and pulmonary function helps assess the severity of the PE. (Moore AJE 2018) Quantification of the pulmonary obstruction allows for further risk stratification. Even though CTPA is cost-effective and widely available, some of the limitations include the use of ionizing radiation with a relatively high radiation dose. It is also contraindicated in patients with an allergy to iodinated contrast media and impaired renal function. The purpose of this study is to find out various common observations of CT pulmonary angiography in suspected cases of a pulmonary embolism that could accurately determine the choice of management by the clinician.

MATERIAL AND METHODS

The present cross-sectional study was performed on 50 patients in the Department of Radiodiagnosis, Sri Aurobindo Medical College & Postgraduate Institute, Indore (MP), from 1st April 2021-30 September 2022.

Patients referred to the Department of Radiodiagnosis for CTPA from various departments with clinically suspected PE of our institute were included after taking written informed consent.

Patients with allergies to contrast agents, impaired renal function tests, and pregnancy were excluded.

CT images were obtained with a SIEMENS 64-slice multi-detector CT scanner (somatom definition AS). Images were reconstructed into 3D, axial, coronal, sagittal maximum intensity projection (MIP) sections and volume rendering technique (VRT). The axial as well as reformatted coronal and sagittal images were evaluated.

All the data were analyzed using IBM SPSS ver. 25 software. Descriptive statistics will be carried out to identify the characteristics and features of the collected data. Mean and percentage were used to represent the data. The chi-square test was applied to identify the association between variables. P value < 0.05 was considered statically significant.

RESULTS

The prevalence of pulmonary embolism in the 50 patients who presented with symptoms of suspicion of pulmonary embolism and underwent MDCT-PA was 26 (52%).

The incidence of clinical suspicion of PE was highest in patients older than 60 years [8 (30.8%)], followed by those with ages between 31-40 years [6 (23.1%)]. However, no significant difference was obtained in age distribution for the incidence of PE (p=0.348). There were 33 (66%) males and 17 (34%) females. Numerically, the incidence of clinical suspicion of PE was highest in the male population [10 (30.3%)] than in females (p=0.662).

Table 1: Comparing symptoms distribution with clinical suspicion of PE

Symptoms	Pulmonary Embolism		Total	P value
	Present	Absent		
Dyspnoea	18 (69.2)	16 (66.7)	34 (68)	0.023
Chest Pain	4 (15.4)	6 (25)	10 (20)	
Cough	3 (11.5)	1 (4.2)	4 (8)	
Hemopstysis	1 (3.8)	1 (4.2)	2 (4)	
Total	**26 (100)**	**24 (100)**	**50 (100)**	

Out of 26 patients who had a pulmonary embolism, 6 (23.1%) patients had a history of DVT, 4(15.4%) had a history of immobilization, 3 (11.5%) had a history of previous surgeries, 3 (11.5%) had a history of pregnancy or post- partum state, 2 (7.7%) had a history of oral contraceptive pills intake, 1 (3.8%) had a history of malignancy. 7 (26.9%) of the patients had no significant history.

D-Dimer Testing

Out of the 50 patients, the D-dimer test was not done in 10 because of the hemodynamic instability in those cases. These 10 cases were directly taken for the CTPA without undergoing D dimer testing. In the remaining 40 cases, a D-dimer test was performed before the patient was taken for CT pulmonary angiography. The statistics were calculated for these 40 cases which had undergone D-dimer testing.

Table 2: Findings of the D-dimer testing

D Dimer	Pulmonary Embolism		Total
	Present	**Absent**	
Above The Cut-off	17	22	39
Below The Cut-off	0	1	1
Total	**17**	**23**	**40**

Of 40 cases, 39 cases had D-dimer values more than the cut-off value of 0.5 micrograms per ml FEU. But in those 39 cases, 17 cases were shown positive for PE on CT pulmonary angiography. Rests 22 were negative for pulmonary embolism. In the 1 case, in which D-dimer levels were less than 0.5 micrograms per ml FEU, there was no evidence of pulmonary embolism on CT pulmonary angiography. The sensitivity, specificity, positive predictive value, and negative predictive value of D-dimer in predicting PE in the present study were 100%, 4.5%, 46.2%, and 100%, respectively.

Out of 26 patients who had a pulmonary embolism, 16 (61.5%) patients had right ventricular enlargement whereas 10 patients (38.5%) did not have right ventricular enlargement. This parameter is important as it indicates right ventricular strain and is a sign of possible pulmonary arterial hypertension.

Table 3: Frequency and Percentage of Anatomical Distribution of Embolus

Subgroup	Frequency	Percentage
Pulmonary Trunk	5	4.6
Right Pulmonary Artery	23	21.1
Left Pulmonary Artery	21	19.3
Bilateral Lobar Artery	18	16.5
Right Lobar Arteries	8	7.3
Left Lobar Arteries	7	6.4
Bilateral Segmental Artery	13	11.9
Right Segmental Artery	4	3.7
Left Segmental Artery	3	2.8
Bilateral Subsegmental Artery	3	2.8
Right Subsegmental Artery	2	1.8
Left Subsegmental Artery	2	1.8
Total	**109**	**100.0**

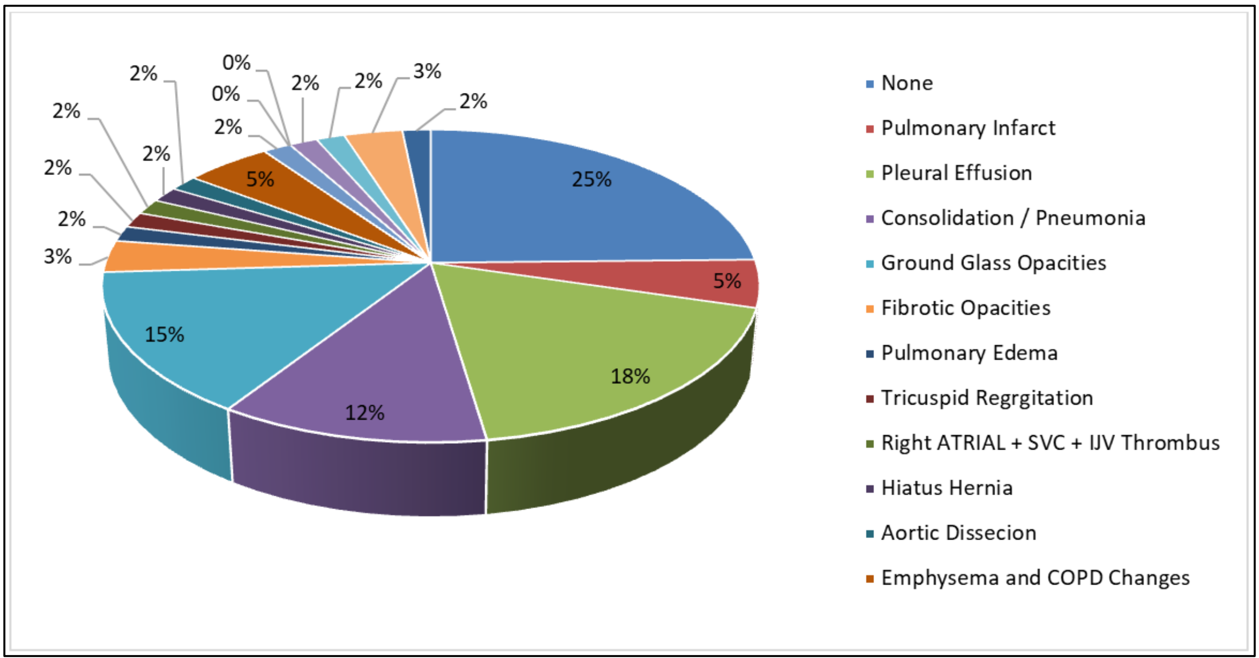

Figure 1: Other parenchymal and pleural findings on MDCT-PA

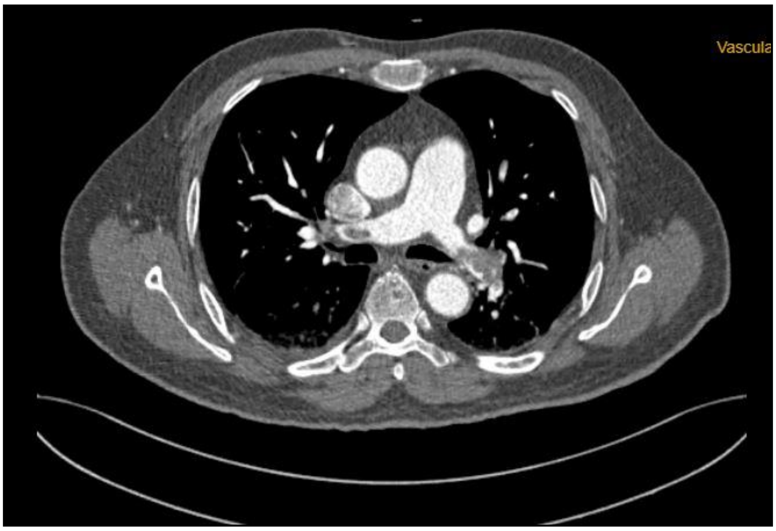

Figure 2: CT pulmonary angiography, axial image shows near complete occluding thrombus in right and left main branches of pulmonary artery (seen as hypodense filling defect)

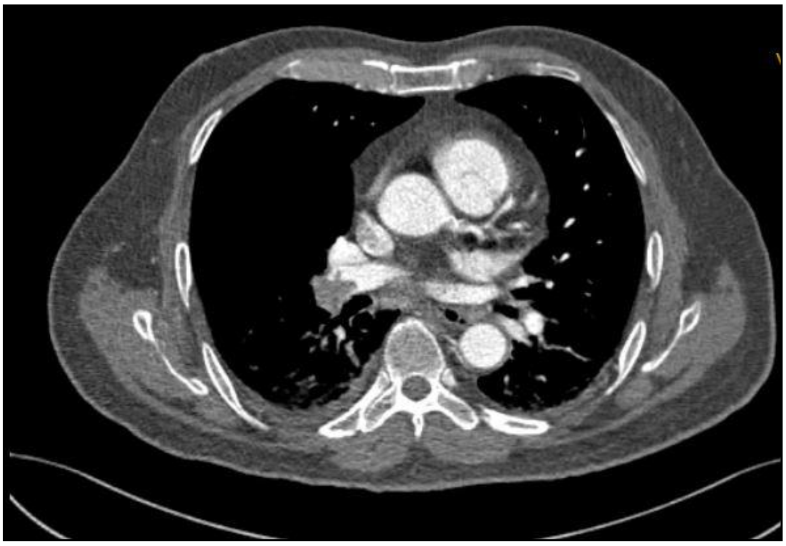

Figure 3: CT pulmonary angiography, axial image shows near complete occluding thrombus in right main pulmonary artery before bifurcation

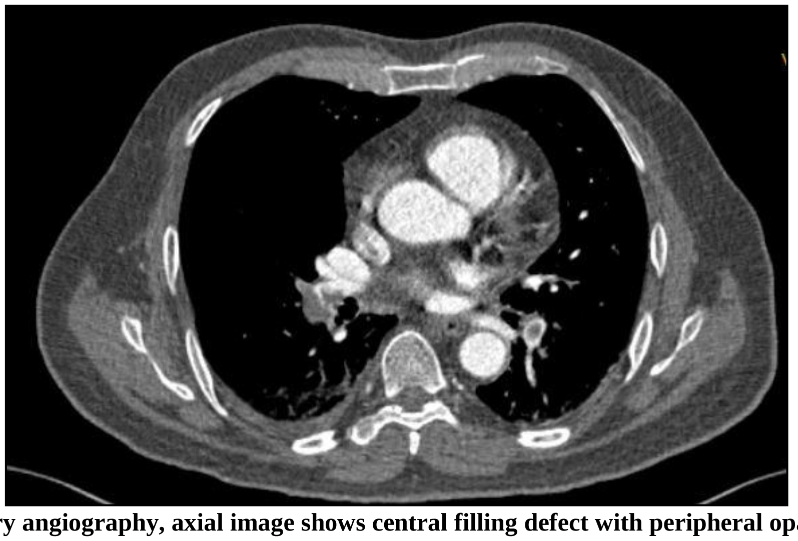

Figure 4: CT pulmonary angiography, axial image shows central filling defect with peripheral opacification in left lower lobar branch (polo mint sign) and complete occluding filling defect in right lobar branch

DISCUSSION

Early diagnosis of the PE and treatment with anticoagulants show promising results in the patient outcome. Pulmonary embolism has very high morbidity and mortality as it is a potentially life-threatening condition (Bhgwat, K. A. 2018). Diagnosis of PE based on clinical history and laboratory data alone is challenging as it presents nonspecific symptoms and includes a list of differential diagnoses. So imaging plays a very important role in the diagnosis of PE. For over a decade, CTPA has played an important role and is considered a primary diagnostic tool in the suspected cases of PE. CTPA is non-invasive, requires a short duration, and has high sensitivity and specificity in diagnosing PE (Lei M 2021).

In the present study, out of 50 patients with clinical and laboratory suspicion of acute pulmonary thromboembolism, MD-CTPA showed PE in 26 patients (52% cases). The prevalence in the present study is comparable to Hogg *et al.*, where the diagnosis of PE was performed using CTPA; the prevalence ranged between 17% and 79 %. (Hogg K 2006) In a similar study by Mos *et al.*, using quantitative D Dimer assay, Wells clinical decision rule, and CTPA, the prevalence was found to be 33% (Mos IC 2014).

In our study, more patients were less than 30 years of age, and fewer were in the range of 51-60. The age range of the patients who participated in our study was 2 years to 90 years. Tambe J *et al.*, performed a study with 37 cases of acute PE with MDCT, and the mean age of these patients was 47±0.5 years (age range 33 to 65 years) (Tambe J 2012). Stein *et al.*, studies the incidence of DVT and PE and reported that incidence increases exponentially with age. There was no age without any risk for venous thromboembolism. The study proves even children below 10 years show the risk for PE and deep vein thrombosis. Therefore, although it is uncommon in infants and children, age does not exclude the diagnosis of PE (Stein PD 2010)..

In our study, more male cases were suspected of having pulmonary thromboembolism than female patients. Of the 33 male patients who had undergone CTPA, 10 were positive for PE. Out of the 17 female patients who had undergone CTPA, 8 were positive for PE. However, Tambe *et al.*, reported female preponderance (Tambe J 2012).

Similarly, Stein *et al.*, reported that the PE diagnosis rate, not adjusted for age, was higher in females (60 PE/1,00,000 women) than in men (42 PE/ 1,00,000 men). However, there was no significance of gender criteria for PE in their study (Stein PD 2010).

In our study, there was a significantly higher number of patients who presented with dyspnea, and the number was significantly higher than other symptoms like chest pain, cough, and hemoptysis.

Lee *et al.*, studied the risk factors in patients with clinical suspicion of PE. Of 116 patients, 14% were found to have PE on CTPA. Immobilization, history of deep vein thrombosis (DVT), and cardiac disease were the three main risk factors reported in their study (Lee EY 2011). In our study, 26.9% of patients had no significant history or risk factors related to PE. In 6 patients (23.1 %), deep vein thrombosis was found, and 15.4% reported a history of immobilization was seen. 11.5% had a history of previous surgeries, 11.5% had a history of pregnancy or post-partum state, 7.7% had a history of oral contraceptive pills intake, and 3.8% had a malignancy.

The present study found that the D dimer testing has high sensitivity and negative predictive value for PE, but the test lacks specificity. The sensitivity and negative predictive value calculated from our study are comparable to that in Perrier *et al.*, study, where 198 patients were studied (Perrier A 1997). Their study's sensitivity, specificity, and negative predictive value were 99.5 %, 41%, and 99%, respectively. The laboratory cut-off value taken in the study was 0.5 micrograms per ml fibrinogen equivalent units (FEU). The study concluded that the specificity of the raised D dimer value can be increased to 93% by increasing the cut-off value to 4000 micrograms per ml FEU (Perrier A 1997).

Out of 26 patients with PE, the majority had (61.5%) right ventricular enlargement. Right ventricular enlargement is an important parameter because it indicates a right ventricular strain pattern due to pulmonary hypertension, which can be attributable to acute PE. Becattini *et al.*, defined right ventricular dysfunction at MDCT as the right-to-left ventricular dimension ratio, which proved that the right-to-left ventricle dimension ratio> or = 0.9 at MDCT had a 92% sensitivity for the right. MD-CTPA can be used as a single tool for diagnosis and risk stratification in cases of acute PE. The significance of the study was that patients with left ventricle dysfunction were considered high- risk patients and needed hospital treatment. In contrast, patients without left ventricle dysfunction have low risk and can be managed with home care (Becattini C 2014). Kumamaru *et al.*, performed a retrospective study with 200 patients to compare the prognostic accuracy of subjective assessment and objective measurement in cases of acute PE. The study showed higher specificity (55.4- 67.7%) for subjective right ventricle enlargement assessment than objective measures (45.8-53.1%) (Kumamaru KK 2012).

In the present study, the most common artery to be involved in PE was the right pulmonary artery. Lee *et al.*, reported that the level of thrombus of PE was segmental in 16 of 31 PEs (52%), lobar in 8 (26%), subsegmental in 5 (16%), and in main or central in 2 (6%) (Lee EY 2011). Kritsaneepaiboon *et al.*, studied 84 children with PE. All these 84 CTPA examinations were technically successful in visualizing the pulmonary tree up to the level of segmental pulmonary arteries. Of 84 children, 13 (15.5%) were positive for PE on CTPA imaging. PE was localized in a lobar artery in 12 (39%), the segmental pulmonary artery in 11 (35%), the sub-segmental pulmonary artery in five (16%), and the main pulmonary artery in three (10%) patients (Kritsaneepaiboon S 2009).

Lee *et al.*, also studied the frequency and other types of diagnoses in the cases suspected of PE. Out of 96 cases, 41% did not have any other diagnoses. In the remaining 57 cases, an alternative diagnosis was found. The list includes atelectasis (22), pneumonia (22), malignancy (3), congenital heart disease (2), pulmonary hypertension (2), pericardial effusion (2), pulmonary nodules (1), rib fractures (1), right atrial thrombus (1) and fat embolism. In them, 8 cases of pneumonia, 8 cases of atelectasis, and 1 case of rib fractures have associated pleural effusion. The study concludes CTPA shows other CT findings if present in the cases who are negative for PE (Lee EY 2011). Although pneumonia and atelectasis are the most common variety of other alternative diagnoses may be detected. Kavanagh *et al.*, studied 85 patients and reported significant other diagnoses in 64 (75%). There were 18 cases (21%) of emphysema, 15 cases (18%) of consolidation, 10 cases (12%) of pleural effusion, 7 cases (8%) of segmental or lobar atelectasis, 4 cases (5%) of pulmonary fibrosis, 4 cases (5%) of bronchogenic neoplasm, 2 cases (2.5%) of mediastinal lymphadenopathy, 1 case of pulmonary metastases, 1 case of an arterio-venous malformation and 1 case of pulmonary tuberculosis. All the patients who have undergone CTPA neither showed PE nor any other alternative findings; their chest radiographs did not show any abnormality on chest radiograph. (Kavanagh EC 2004) Also, 17 cases (27%) with other alternate diagnoses on CTPA did not show any abnormality on the chest radiograph. In 34 cases (53%), the findings were concordant with the findings on chest radiographs. In 13 patients, findings seen only on CT included 2 cases of consolidation, 2 cases of bronchogenic carcinoma, 6 cases of emphysema, 1 case of pulmonary fibrosis, 1 case of pulmonary metastasis, and 1 case of mediastinal lymphadenopathy. Similar results were depicted in our study (Kavanagh EC 2004).

The study's main limitations are the cross-sectional nature and limited sample size. There is a need for a large randomized clinical trial to provide more strength to present study findings.

CONCLUSION

In the clinically suspected cases of pulmonary thromboembolism, Multi-detector computed pulmonary tomography angiography was found to be a useful diagnostic tool. CTPA is the modality of choice as it is a rapid, minimally invasive study that is well tolerated. The study's only contraindication is in patients with altered renal function tests. It allows direct demonstration of endoluminal thrombus and the extent of the thrombus in the pulmonary arteries and branch vessels, thereby facilitating the early detection of fatal pulmonary thrombo-embolism and adequate management of the same, thus reducing the morbidity and mortality due to pulmonary thromboembolism. Also, in the patients who are not having PE, the study detects any other parenchymal or pleural pathologies and helps in the management protocols accordingly. CT Pulmonary Angiography, a non-invasive technique, has produced a paradigm shift that has raised the standard of care in patients suspected of PE.

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