Diagnostic Accuracy Study

Medicine®

OPEN

Correlations between computed tomography and positron emission tomography/computed tomography findings and pathology in 6 cases of pulmonary epithelioid angiosarcoma

Xinguan Yang, MD[a], Juhong Jiang, MD[b,c], Xiao Dong, MD[a], Jiamin Liang, MD[a], Yubao Guan, MD, PHD[a,*]

Abstract

Previous studies on primary pulmonary epithelioid angiosarcoma (PEA) have been mostly clinical or pathological case reports. We here summarize findings from computed tomography (CT) and positron emission tomography/computed tomography (PET/CT) analyses of PEA to improve the diagnosis and differentiation of this rare tumor.

We conducted a retrospective analysis of the clinical findings, radiological imaging, and pathological findings of 6 cases of primary PEA confirmed by surgery, biopsy, and pathology. All cases were evaluated by CT and x-ray prior to surgery, and 2 cases were further examined by PET/CT.

CT images indicated maximum tumor diameters of 2.4 to 9.8 cm and inhomogeneous density, with 1 case exhibiting nodular calcification. Contrast-enhanced CT revealed inhomogeneous enhancement with visible necrosis in all 6 cases, while 3 cases had hilar and mediastinal lymph node metastasis. Five cases displayed extensive tumor involvement with extension into the chest wall, mild-to-moderate levels of pleural effusion, and varying degrees of volume loss in the corresponding hemithorax. One case had limited pleural thickening and invasion. Preoperative PET/CT of 1 case revealed abnormal fluorine-18 fluorodeoxyglucose (^{18}F-FDG) uptake by the tumor and multiple enlarged right hilar and mediastinal lymph nodes, right diffuse pleural thickening, and systemic multiple bone metastasis. In the other case, PET/CT scan at 7 months after surgery revealed pleural thickening and mediastinal lymph nodes with increased ^{18}F-FDG uptake on the surgical side. Immunohistochemistry analyses determined that all 6 tumors were positive for CD34, CD31, ERG, and vimentin.

CT and PET/CT findings reveal that malignant characteristics, including extensive pleural thickening, invasion and metastasis, and pleural effusion, are common in PEA. Imaging data are only supportive; therefore, the final diagnosis should be based on pathology and immunohistochemistry analyses.

Abbreviations: ^{18}F-FDG = fluorine-18 fluorodeoxyglucose, HE = hematoxylin-eosin staining, IHC = immunohistochemical, PEA = pulmonary epithelioid angiosarcoma, PET/CT = positron emission tomography/computed tomography, SUVmax = maximum standardized uptake value.

Keywords: computed tomography, epithelioid angiosarcoma, pathology, positron emission tomography, pulmonary tumor, tomography, x-ray

1. Introduction

Epithelioid vascular tumors encompass a spectrum of neoplasms ranging from the benign epithelioid hemangioma, to the low-to-intermediate-grade epithelioid hemangioendothelioma, and the high grade epithelioid angiosarcoma.[1] Epithelioid vascular tumors are most likely to occur in the deep soft tissue and skin of the limbs; however, they may also occur in the digestive tract, breast, bone, kidney, spleen, lungs, and other organs. Previous studies on primary pulmonary epithelioid angiosarcoma (PEA) were mostly clinical or pathological case reports, except for a single positron emission tomography/computed tomography (PET/CT) report (Table 1).[2–6] Herein, we summarized and analyzed the clinical, imaging, and pathological findings of 6 cases of primary PEA and reviewed the associated literature to provide further insights into this rare tumor type.

2. Methods

2.1. Subjects

This retrospective study was approved by our institutional review board, which waived informed consent. Between February 2010 and December 2015, 6 patients were diagnosed with histopathology-confirmed primary PEA in our hospital, including 3 males and 3 females ranging from 25 to 54 years old (mean, 35.17 ± 10.89 years).

Of these 6 patients, subject 1 (male, 40 years) had recurrent chest pain and tightness lasting 5 months, and subject 2 (female, 26 years) had pain in the left chest, shoulder, and then the rest of

Editor: Sergio Gonzalez Bombardiere.

XY and JJ contributed equally to the work and share first authorship.

The authors declare no conflict of interest.

[a] Department of Radiology, [b] Department of Pathology, the First Affiliated Hospital of Guangzhou Medical University, [c] Guangzhou Institute of Respiratory Health, Guangzhou, China.

[*] Correspondence: Yubao Guan, Department of Radiology, the First Affiliated Hospital of Guangzhou Medical University, Guangzhou 510120, China (e-mail: yubaoguan@163.com).

Medicine (2018) 97:35(e12107)

Received: 8 January 2018 / Accepted: 2 August 2018

http://dx.doi.org/10.1097/MD.0000000000012107

Table 1

Summary of the 5 cases of pulmonary epithelioid angiosarcoma reported in the literature.

Author	Gender	Age, y	Clinical manifestation	Pleural involvement	Pathology/ morphology	Lymph node metastasis	Immunohistochemistry			
							CD31	CD34	CK	EMA
Ozcelik	Male	62	Cough, chest pain, fatigue, and bleeding	Yes	Extensive tumor necrosis	Yes	+	–	+	–
Carillo	Male	56	Persistent hemoptysis	Yes	Extensive necrosis, mitotic figures 44/10HPF	Yes	+	+	+	+
Tochigi	Female	50	Asymptomatic	Yes	Cellular atypia, mitotic figures > 3/10HPF	Yes	+	–	+	–
Yang	Male	41	Asymptomatic	Yes	Marked cellular atypia, nuclear fission	No	+	+	–	–
Giorgo	Female	54	Asymptomatic	No	Tumor cell atypia	No	+	No	–	No

the body lasting 7 months without apparent cause. Subject 3 (female, 54 years) had chest tightness lasting 2 weeks. Subject 4 (female, 36 years) had recurrent coughing and chest pain for more than 6 months. Subject 5 (male, 30 years) reported coughing with concurrent weight loss, night sweats, and chest pain for 2 months. Subject 6 (male, 25 years) had no obvious clinical symptoms; however, a physical examination found an unexpected left lung tumor. Of the 6 patients, 4 cases underwent thoracic surgery at our hospital, with 2 cases diagnosed by biopsy. All patients were followed-up postoperatively: Subject 6 survived (59 months) as of the last follow-up, and 4 patients died at 2 months (subject 1), 5 months (subject 5), 7 months (subject 4), and 24 months (subject 2) after pathological diagnosis. Subject 3 was discharged after abandoning treatment and was lost during follow-up.

2.2. Imaging examinations

All patients received digital lateral chest x-ray examinations using a DR system (Definium 6000; GE China Healthcare, Beijing, China). Plain and contrast-enhanced CT (Definition AS+ 128-Slice; Siemens Healthcare, Forchheim, Germany) was performed using the following parameters: tube voltage, 120 kV; automatic tube current modulation (35–90 mAs); pitch, 0.9; field of view, 180 mm × 180 mm; imaging matrix, 512 × 512; and reconstructed slice thickness, 2 mm. The contrast agent iohexol (concentration, 300 mg I/mL) was used at a dose of 1.5 mL/kg, with an injection flow rate of 4.0 mL/s. Contrast-enhanced CT scans were obtained at 30 and 60 seconds after the injection. All 6 patients underwent plain and contrast-enhanced CT scan.

Systemic PET/CT scans were conducted using a Discovery ST (GE Company). PET/CT images were acquired 1 hour after elbow intravenous injection of 5.18 MBq of fluorine-18 fluorodeoxyglucose (^{18}F-FDG) adjusted for body weight. PET/CT scans were acquired in 3D mode (multiple bed positions, 3.0 minutes for each bed position) with the following scanning conditions: 140 KV, 120 mAs; section thicknesses, 3.7 and 2.5 mm; pitch, 0.875.

2.3. Pathological analysis

The tumors were routinely fixed in 10% neutral buffered formalin and embedded in paraffin. Four-micrometer-thick sections were stained with hematoxylin-eosin staining (HE). Immunohistochemical (IHC) analyses were performed using the ChemMate Envision/HRP Kit (Dako, Glostrup, Denmark). Antibodies used in this study were cytokeratin (AE1/AE3), epithelial membrane antigen (EMA), vimentin, S-100 protein, HMB-45, CK7, FVIII, CD31, CD34, EGR, Myo-D1, CD68, CD99, and Ki-67 (see Table 2 for further details).

3. Results

3.1. X-ray findings

X-ray images revealed minor right pleural effusion in 2 cases (subjects 1 and 5) and mild-to-moderate left pleural effusion in another 2 cases (subjects 2 and 3) (Fig. 1A), with patchy and diffuse consolidation in the corresponding lung fields. One case (subject 6) showed a 2.5-mm nodule in the left lung. Another (subject 4) showed a 57-mm mass with mild lobulation in the left lung (Fig. 1A), accompanied by ipsilateral pleural effusion.

3.2. CT findings

As shown in Table 3, peripheral tumors were located on the left upper lobe in 2 cases (subjects 4 and 6) (Figs. 1B, C and 2A, B), on the left lower lobe in 2 cases (subjects 2 and 3), on the right upper lobe in 1 case (subject 5) (Fig. 3), and on the right lower lobes in 1 case (subject 1). The tumors appeared as nodules or masses in all 6 cases, with maximum diameters ranging from 2.4 to 9.8 cm. The tumors had a heterogeneous density, accompanied by nodular calcification in 1 case (Fig. 2B). Enhanced CT scans showed inhomogeneous enhancement with patchy necrosis in all cases. All but 1 case revealed extensive ipsilateral inhomogeneous pleural thickening, invasion into the chest wall and different degrees of thorax volume loss in the ipsilateral hemithorax,

Table 2

Immunohistochemical analysis of the 6 cases of PEA.

Subject	CD31	CD34	EGR	Vimentin	EMA	F VIII	CK	CK7	Ki67	HMB45	S-100
1	+++	+++	+	+	Focal+	Focal+	–	–	10% +	–	–
2	+	Focal+	+	+	Focal+	Focal+	–	–	No	–	–
3	+	+	+	+	–	–	–	–	30% +	–	–
4	+	+++	+	+	Focal+	–	+	+	Negative	–	–
5	+	+	+	+	Focal+	Focal+	–	–	20% +	–	–
6	+	+++	+	+	Focal+	–	+	+++	30% +	–	–

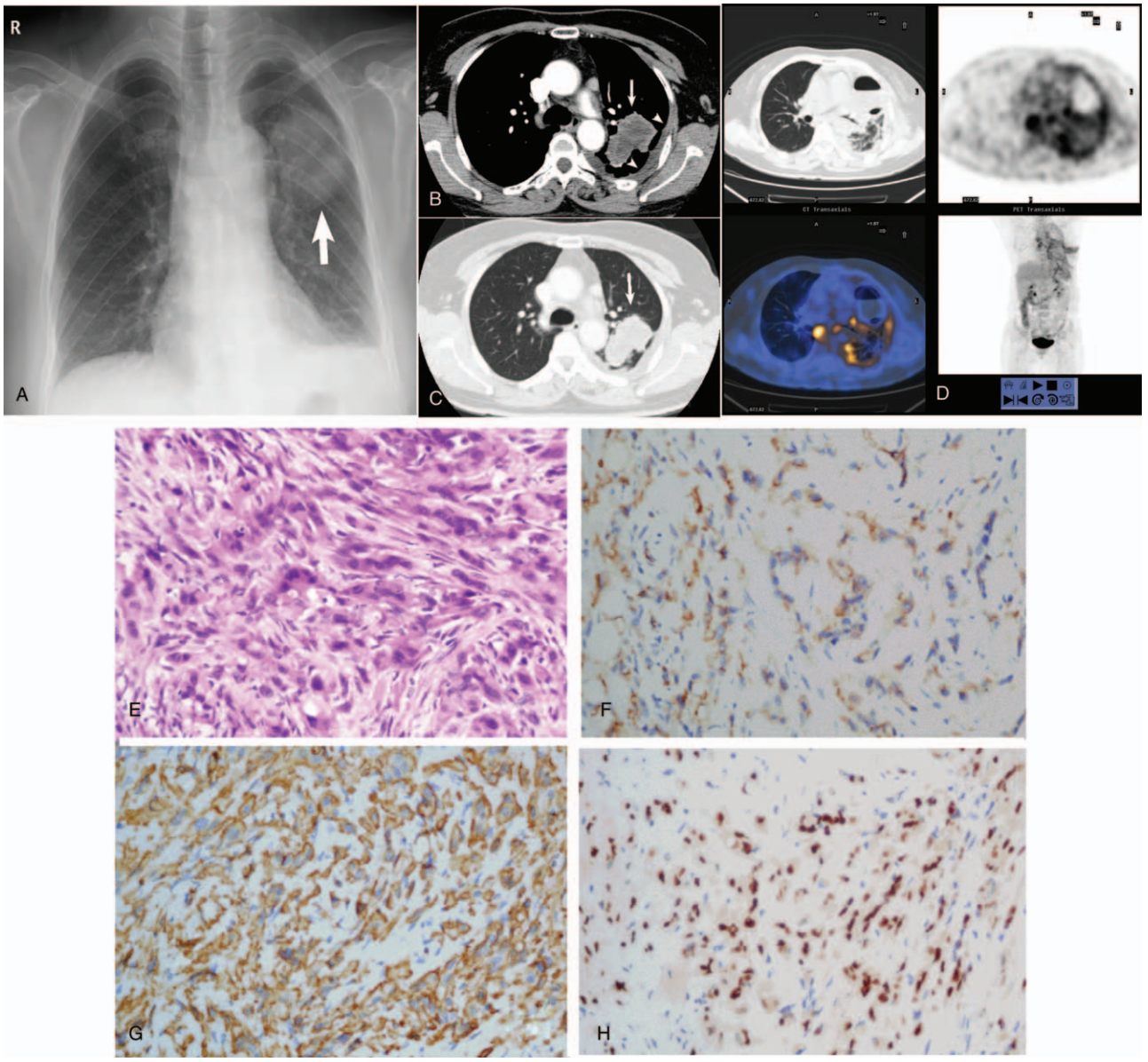

Figure 1. A 36-year-old female presented with chest tightness that had lasted for 2 weeks (subject 4). A, The chest radiograph shows a mass shadow (long arrow) in the left upper field with slight lobulation at the edge and slight pleural effusion and mild volume loss in the left hemithorax. B, Contrast-enhanced CT shows inhomogeneous enhancement mass with low-density patchy necrosis (long arrow) in the left upper lobe, slight ipsilateral pleural effusion and pleural thickening of the left chest wall (arrowheads). C, CT (pulmonary window) shows soft tissue masses in the upper lobe of the left lung, with lobulation at the edge (long arrow). D, PET/CT examination at 7 months postoperatively. Multiple mediastinal lymph nodes show abnormal ^{18}F-FDG uptake with SUVmax of 4.8 to 6.4, and the left pleura shows diffuse thickening with SUVmax of 4.6 to 6.4. E, Pathological analysis revealed flaky epithelioid tumor cells with enlarged nuclei, marked atypical, and abundant red-staining in the cytoplasm with tiny vacuoles (HE × 400). F–H, Cytoplasm of tumor cells stained positively diffusely for CD31 (F) and CD34 (G); nuclei of tumor cells stained positively for EGR (H) (IHC × 400).

accompanied by mild-to-moderate pleural effusion. One case (subject 1) had a left pneumohydrothorax due to aspiration by the needle; one case (subject 6) had limited pleural traction and thickening, and 3 cases (subjects 1, 3, and 5) had hilar and mediastinal lymph node metastasis.

3.3. PET/CT findings

A patchy lesion was observed preoperatively in the right upper lobe in subject 5, with a significantly high ^{18}F-FDG uptake at the maximum standardized uptake value (SUVmax) of 11.2 (Fig. 3D). Furthermore, right hilar and mediastinal lymph node enlargement was observed, with the greatest short diameter of approximately 0.6 to 1.1 cm and abnormal SUVmax ranging from 3.6 to 7.0. Diffuse thickening of the right pleura, with abnormal SUVmax of 5.8 in conjunction with systemic multiple bone metastases. Subject 4 underwent PET/CT examination at 7 months postoperatively. The left pleura showed diffuse thickening with SUVmax of 4.6 to 6.4, and multiple mediastinal lymph nodes had increased ^{18}F-FDG uptake with SUVmax of 4.8 to 6.4. Increased 18F-FDG uptake was observed in the left chest wall and the SUVmax was 6.2 (Fig. 1D).

Table 3

CT findings for the 6 cases with PEA in this series.

Subject	Site	Morphology	Size, cm	Enhancement	Pleural invasion	Pleural effusion	Invasion of chest wall	Volume loss of thorax	Hilar and mediastinal lymph node enlargement
1	Lower lobe of right lung	Irregular	$5.1 \times 4.1 \times 3.2$	Heterogeneous enhancement, large area of patchy necrosis	circumferential and nodular thickening	Mild	Yes	Yes	Yes
2	Lower lobe of left lung	Irregular	$2.4 \times 2.2 \times 2.2$	Slightly heterogeneous enhancement	circumferential and nodular thickening	Mild	Yes	Yes	No
3	Lower lobe of Left lung	Irregular	$7.2 \times 3.4 \times 6.3$	Heterogeneous enhancement, large area of patchy necrosis	circumferential and nodular thickening	Moderate	Yes	Yes	No
4	Upper lobe of left lung	Irregular	$5.7 \times 4.4 \times 5.6$	Heterogeneous enhancement, large area of patchy necrosis	circumferential and nodular thickening	Mild	Occurred after 7-month-follow-up	Yes	Yes
5	Upper lobe of right lung	Large patchy	$9.8 \times 5.5 \times 7.4$	Heterogeneous enhancement, large area of patchy necrosis	circumferential and nodular thickening	Mild	Yes	Yes	Yes
6	Upper lobe of left lung	Round-like calcification	$2.0 \times 2.5 \times 1.6$	Heterogeneous enhancement, necrosis area	Local thickening	no	No	No	No

3.4. Surgery, biopsy, pathology, and IHC examinations

The tumors of 4 cases were resected, and 2 cases were confirmed as PEA by biopsy. The boundaries of the surgically excised tumors were ambiguous in 4 cases, with the gray/yellow excised surface showing visible hemorrhage and necrosis. Under microscopic examination, the tumor boundary was ambiguous with diverse morphology. We also observed a diffuse and patchy distribution of epithelioid cells throughout most of the tumors with focal necrosis, massive, red-stained cytoplasms, and enlarged nuclei, which demonstrated signs of significant atypia nuclear fission (≥3/10 HPF) (Fig. 1E). Vacuoles were located within the cytoplasm and erythrocytes were occasionally visible in some tumor cells. In the 4 cases that underwent surgery, multiple tumor thrombi were visible in the adjacent lung tissue, with lymphatic vessels beneath the tracheal mucous membrane; pleural thickening, adhesion, and invasion also observed. IHC analysis revealed that CD31, CD34, and EGR were highly expressed within the vascular endothelial cells as the source of the tumors in all 6 cases (Fig. 1F–H).

4. Discussion

Angiosarcoma is a rare, highly malignant vascular tumor that originates from the vascular endothelium and accounts for 1% to 2% of soft tissue sarcomas.[7] Angiosarcoma mainly occurs in the skin and soft tissues but can also arise within the digestive tract, breast, bone, kidney, spleen, lungs, and other internal organs. To the best of our knowledge, more than 30 cases of primary pulmonary angiosarcoma have been reported to date,[8] which have mainly been confirmed based on pathological diagnosis.

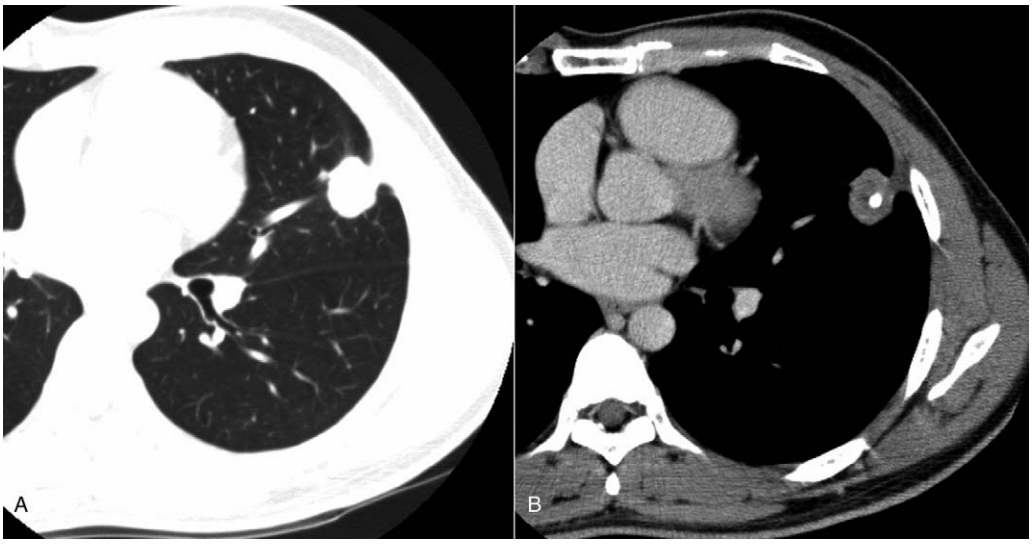

Figure 2. A 25-year-old male presented with a left lung nodule detected by physical examination (subject 6). A, CT shows a nodule in the lingular segment of the left upper lobe with pleural indentation. B, Contrast-enhanced CT shows edge enhancement of the lesion, with nodular calcification, and adjacent local pleura thickening.

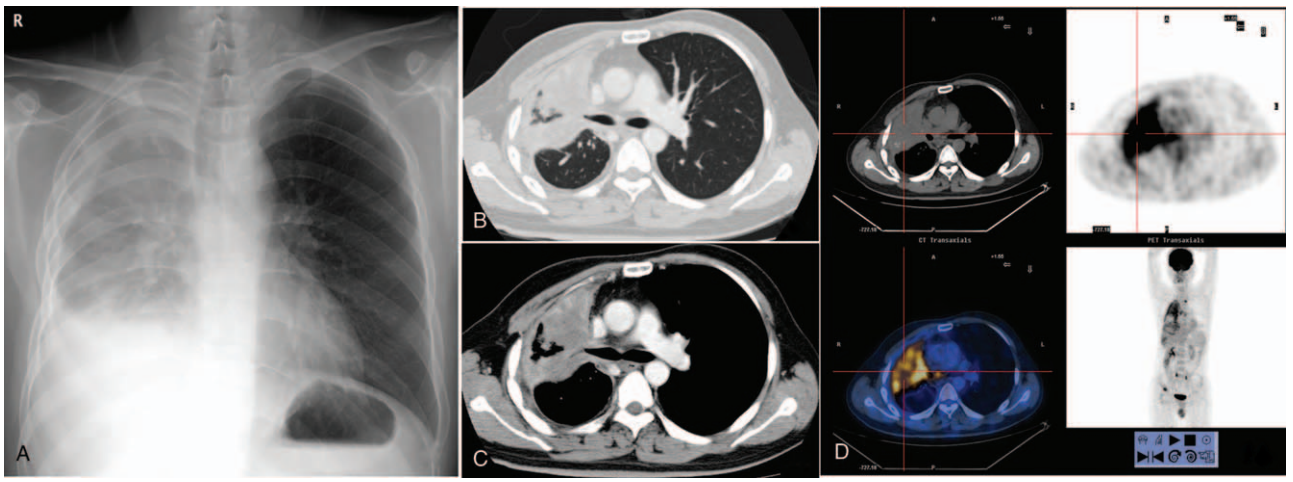

Figure 3. A 30-year-old male presented with a cough, weight loss, and night sweats that had lasted 2 months (subject 5). A, The chest radiograph shows a large patchy opacity in the right lung, mild pleural effusion, and mild volume loss in the right hemithorax. B, CT image shows a large patchy consolidation with inhomogeneous density in the upper lobe of the right lung. C, Contrast-enhanced CT image shows heterogeneous enhancement consolidation in the right upper lobe, with extensive irregular thickening of the right pleura. D, PET/CT scan shows the patchy lesion in the right upper lobe lesion with a significantly high FDG of SUVmax 11.2, diffuse right pleural thickening with SUVmax 5.8 and multiple systemic bone metastases.

PEA is a very rare type of angiosarcoma, with a structure characterized by epithelial cells. Based on the literature, PEA mainly occurs in males, and the majority of patients are aged 40 years or older. In this study, an equal ratio of male and female subjects were enrolled, and the average age of diagnosis was 35 years. The main clinical manifestations included cough, chest pain and chest tightness, although 5 subjects were asymptomatic, which was consistent with findings in the literature.[2–6]

Shimabukuro et al[8] summarized information about 32 cases of pulmonary angiosarcoma (including epithelioid angiosarcoma). In that study, CT findings revealed mainly solitary pulmonary nodules or masses of different sizes (12–100 mm), multiple nodes in both lungs, diffuse, and patchy consolidation in 1 or more lobes, and ground-glass opacities with or without pleural effusion. However, in the reported cases, there was a lack of specific signs for pulmonary angiosarcoma, and the majority of tumors were single masses or multiple nodules in the lungs (21/32). In our study, all 6 cases had solitary lung nodules or masses with circular or irregular contours and of heterogeneous density. Enhanced CT scans revealed heterogeneous enhancement and visible necrotic areas. Moreover, the duration of clinical symptom onset was relatively short in all cases. Five cases had diffuse pleural thickening, pleural effusion, chest wall invasion, and ipsilateral thorax volume loss, while the sixth case showed small lesions (T2aN0M0) but also displayed limited pleural thickening and invasion. Thus, this case review suggested that PEA is highly malignant and invasive and is mostly located in the lung periphery, increasing the likelihood of invasion to the pleura or pleural metastasis and pleural effusion. We speculated that pleural involvement might be linked to multiple tumor thrombi of the adjacent lung tissue and lymphatic vessels. In this study, three cases had hilar and mediastinal lymph node enlargement, consistent with findings from previous literature reports.[8]

Treglia et al[5] reported a single case of PEA with abnormally increased ^{18}F-FDG uptake (SUVmax, 13) for the lesions identified using PET/CT. In this study, 1 case underwent preoperative PET/CT examination, revealing abnormal radioactive uptake by the tumor and multiple enlarged right hilar and mediastinal lymph nodes, diffuse right pleural thickening, and systemic multiple bone metastasis. In another case, the 7-month postoperative PET/CT scan revealed pleural thickening and increased radioactive uptake on the surgical side and in the mediastinal lymph nodes. PET/CT examination exhibits high sensitivity and specificity for diagnosis of malignant tumors and detection of distant metastasis. Therefore, PET/CT is an important reference for the determination of preoperative staging and prediction of postoperative recurrence and metastasis.

The main pathological manifestations of PEA include diffuse patchy distributions of spindle cells, abundant cytoplasm of cancer cells, prominent capillary-like vasoformative elements, hemorrhage pools, papillary growth, prominent nucleoli, and marked atypical nuclei. In the limited small samples used for biopsy, the lack of these histological features may present a diagnostic challenge in differentiating vascular tumors from carcinoma and malignant mesothelioma. Immunohistochemical demonstration of vascular differentiation is very useful for the diagnosis of PEA, which is generally positive for common vascular-origin markers, including CD31, CD34, EGR, and FVIII. CD31-positive staining has a high sensitivity and specificity; 90% of cases were positive. In this study, all 6 cases were positive for CD31, CD34, and EGR, and 3 cases were FVIII-positive. Todd et al[1] consider CD31 and ERG to be the most reliable markers of vascular differentiation. All tissue specimens used in this study were positive for CD31 and EGR staining, which was similar to previous reports. CK expression for epithelial origin was seen in 2 of 6 cases.

During follow-up, four patients died within 2 years, one patient discontinued treatment and was discharged before being lost to follow-up, and one patient was still alive 59 months postoperatively, despite the development of postoperative adjacent pleural invasion. Todd et al[1] reported that pleural involvement correlated with worse prognosis. Five cases with pleural involvement in this study had poor prognoses, which was consistent with the literature. Therefore, early discovery, diagnosis, and treatment may play a significant role in improving the prognoses of patients with PEA.

PEA should be distinguished from certain diseases that exhibit similar characteristics. Pleural invasion that occurs in lung cancer

is often limited and has a lower frequency of thoracic volume loss. In addition, lung cancer is characterized by lobulation or spiculation at tumor edges, but sometimes it is difficult to identify preoperatively in advanced lung cancer. Malignant pleural mesothelioma is characterized by extensive nodular or circumferential pleural thickening with massive pleural effusion. Ossification or calcification may also be seen in regions of pleural thickening or pleural masses of pleural mesothelioma.[9] Other primary pulmonary sarcomas, such as fibrosarcoma, rhabdomyosarcoma, and leiomyosarcoma, are often characterized by massive masses located in the lung periphery and lack signs of spiculation and calcification. They also rarely exhibit lymph node metastasis in the hilar and mediastinum, and mild-to-moderate enhancement with smaller necrotic areas is observable on contrast-enhanced CT.

Some limitations of the study should be acknowledged. First, the study was a retrospective analysis, not all of the medical examinations were complete for all cases, and only two cases underwent PET/CT. Second, due to the limited number of patients in our study, additional case series should be evaluated, which would determine whether PEA has other unique imaging characteristics.

5. Conclusions

In summary, the imaging findings of PEA include a peripheral pulmonary nodule or mass; heterogeneous enhancement; lesions prone to necrosis; significant pleural invasion, metastasis and pleural effusion; signs of thoracic collapse; hilar and mediastinal lymph node metastasis; and whole-body bone metastasis. The final diagnosis of PEA relies on pathological and immunohistochemical examinations. Chest CT provides an important reference for tumor characterization and its extent, and an assessment of surgical resectability. PET/CT plays an important role in guiding preoperative staging or selection of treatment protocols, such as radiotherapy or chemotherapy, evaluating the general condition, and determining the extent of distant metastases and recurrence.

Author contributions

Conceptualization: Xinguan Yang, Yubao Guan, Juhong Jiang.
Project administration: Yubao Guan.
Resources: Xinguan Yang, Xiao Dong, Jiamin Liang.
Data curation: Juhong Jiang, Xiao Dong, Jiamin Liang.
Formal analysis: Jiamin Liang.
Investigation: Xiao Dong.
Supervision: Yubao Guan.
Validation: Juhong Jiang.
Writing – original draft: Xinguan Yang, Xiao Dong, Jiamin Liang.
Writing – review & editing: Xinguan Yang, Yubao Guan, Juhong Jiang.

References

[1] Anderson T, Zhang L, Hameed M, et al. Thoracic epithelioid malignant vascular tumors: a clinicopathologic study of 52 cases with emphasis on pathologic grading and molecular studies of WWTR1-CAMTA1 fusions. Am J Surg Pathol 2015;39:132–9.
[2] Ozcelik C, Onat S, Yaldiz M, et al. Primary epithelioid angiosarcoma of the lung presenting as pulmonary hemorrhage. Asian Cardiovasc Thorac Ann 2006;14:69–71.
[3] Carillo GA, Carretero MA, Vazquez JE, et al. Epithelioid angiosarcoma of the lung with pleural metastases: a rare cause of haemoptysis clinicopathological conference. Heart Lung Circ 2010;19:624–8.
[4] Tochigi N, Tsuta K, Maeshima AM, et al. Malignant pulmonary epithelioid hemangioendothelioma with hilar lymph node metastasis. Ann Diagn Pathol 2011;15:207–12.
[5] Treglia G, Cardillo G, Graziano P. A rare case of primary pulmonary epithelioid angiosarcoma detected by (18)F-FDG PET/CT. Clin Nucl Med 2014;39:450–2.
[6] Yang CF, Chen TW, Tseng GC, et al. Primary pulmonary epithelioid angiosarcoma presenting as a solitary pulmonary nodule on image. Pathol Int 2012;62:424–8.
[7] Young RJ, Brown NJ, Reed MW, et al. Angiosarcoma Lancet Oncol 2010;11:983–91.
[8] Shimabukuro I, Yatera K, Noguchi S, et al. Primary pulmonary angiosarcoma presenting with hemoptysis and ground-glass opacity: a case report and literature review. Tohoku J Exp Med 2015;237:273–8.
[9] Nickell LTJr, Lichtenberger JP3rd, Khorashadi L, et al. Multimodality imaging for characterization, classification, and staging of malignant pleural mesothelioma. Radiographics 2014;34:1692–706.