Atypical radiological manifestations of thoracic metastasis: the unusual of the common.

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Authors: L. López-Calderón\textsuperscript{1}, M. L. Domingo\textsuperscript{2}, S. Isarria Vidal\textsuperscript{3}, R. J. Rodelo\textsuperscript{2}, J. A. Gonzalez-Nieto\textsuperscript{2}; \textsuperscript{1}Valencia, Valencia/ES, \textsuperscript{2}Valencia/ES, \textsuperscript{3}Valencia, VA/ES
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Learning objectives

To show atypical radiological manifestations of thoracic metastasis based on histopathological origin, metastatic mechanism and after administration of treatment.
Background

Pulmonary metastasis are seen in 20-54% of extrathoracic malignancies. Lungs are the second most frequent site of metastases from extrathoracic malignancies. Twenty percent of metastatic disease is isolated to the lungs. The common tumours which metastasise to the lung include renal, breast, colon, and prostate carcinomas, as well as sarcomas.

The development of pulmonary metastases in patients with known malignancies indicates disseminated disease and places the patient in stage IV in TNM (tumor, node metastasis) staging systems. This typically implies an adverse prognosis and alters the management plan and imaging studies plays an important role in the screening and detection of pulmonary metastases.
Findings and procedure details

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Thoracic metastases are produced by 5 mechanisms: by pulmonary, bronchial and thoracic arteries, lymph vessels, pleural space, airway and direct invasion.

Typical pulmonary metastases usually occur by hematogenous route and appear as multiple nodules predominantly of peripheral and basal distribution, rounded morphology and variable size (Fig. 1 on page 8). Another common form is via the lymphatic system presenting as diffuse interstitial thickening (carcinomatous lymphangitis) (Fig. 2 on page 8).

It is possible to find metastases with an unusual radiologic appearance, depending on metastatic mechanism and histopathological origin, making it difficult to distinguish them from other nonmalignant pulmonary processes.

These atypical findings include solitary mass, airspace consolidation, nodules with poorly defined or irregular margins, cavitation and cystic degeneration, calcifications, ground-glass opacity around metastatic nodules, thrombotic microangiopathy and endobronchial tumor metastasis.

Other manifestations to consider include thoracic lymph node involvement, pleural metastasis, benign processes that metastasize to the lung and the atypical aspect that can develop lung metastases after treatment.

**Cavitation:**
Squamous cell carcinomas are regarded as the most common type of cavitating metastases observed on radiographs, composing 69% of cavitating metastases however, cavitation can also be encountered in metastatic adenocarcinomas of the gastrointestinal tract and breast. Sarcomas can also cavitate, and even produce pneumothorax.

Cavitation is presumed to be either due to tumor necrosis or a check-valve mechanism that develops by means of tumor infiltration into the bronchial structure. The wall of a cavitated mass is generally thick and irregular, although thin-walled cavities can be found with metastases from sarcomas and adenocarcinomas. (Fig. 3 on page 9  Fig. 4 on page 10)

**Calcification:**

Calcification can occur in metastatic nodules from an osteosarcoma or chondrosarcoma, synovial sarcoma, giant cell tumor of the bone; and carcinomas of the colon, ovary, breast and thyroid. Several mechanisms are responsible for calcification: bone formation in an osteosarcoma or chondrosarcoma; dystrophic calcification in a papillary carcinoma of the thyroid, giant cell tumor of the bone, synovial sarcoma, or treated metastatic tumor; and mucoid calcification in a mucinous adenocarcinoma of the gastrointestinal tract and breast. (Fig. 5 on page 11)

**Hemorrhage:**

Pulmonary metastasis with peritumoral hemorrhage has nodular attenuation surrounded by a halo of ground-glass opacity on CT (halo sign) or ill-defined fuzzy margins. A halo of ground-glass opacity is not a specific finding, and may also be found in other diseases.

Angiosarcomas, choriocarcinomas renal cell carcinomas and melanoma are representative causes of hemorrhagic metastases. Fragility of the neovascular tissue that leads to a rupture of the vessel is a probable cause for hemorrhage around the metastasis. (Fig. 6 on page 12)

**Consolidation (air-space pattern):**

Can be due to lepidic growth of tumor along intact alveolar walls, which is seen in metastatic adenocarcinoma from GI tract, ovary, or breast. Imaging features include consolidation with air bronchography, ground-glass opacities, and air-space nodules. (Fig. 7 on page 13, Fig. 8 on page 14). Another mechanism is pulmonary infarction due to tumor embolism, which is seen in tumors of the liver, breast, kidney, stomach, and prostate, as well as in choriocarcinoma.
**Tumor embolism:**

Less common presentation of metastatic disease. With tumor emboli, the tumor is confined to the vascular tree, without proliferation of metastasis into extravascular tissue. Tumor emboli is seen in metastasis from liver, breast, renal, gastric, and prostatic cancers, as well as in sarcomas and choriocarcinomas. Tumor emboli are seen in small or medium-sized arteries. Large tumor emboli within main, lobar, or segmental pulmonary arterial branches are only rarely seen. The CT findings reported for tumor emboli include multifocal dilatation and beading of the peripheral subsegmental arteries and peripheral wedge-shaped areas of attenuation due to infarction. (Fig. 9 on page 15)

**Miliary Nodules:**

Miliary nodules refer to numerous, small 1-4 mm, same-sized nodular opacities that resemble millet seeds. Miliary metastases are seen in cancers of the thyroid (medullary carcinoma), kidney, breast, and pancreas, as well as in malignant melanoma, osteosarcoma, and trophoblastic disease. They are believed to be caused from a single massive shower of tumor emboli. Miliary nodules are seen in a random distribution within the secondary pulmonary lobe and involve the subpleural regions. (Fig. 10 on page 16) The differential diagnosis for miliary nodules includes granulomatous infections such as tuberculosis, histoplasmosis, healed varicella pneumonia, sarcoidosis, silicosis, coal worker's pneumoconiosis, hypersensitivity pneumonitis, and Langerhans cell histiocytosis.

**Dilated Vessels within a Mass:**

Sometimes dilated, tortuous, and tubular enhancing structures within the metastatic nodule are observed at contrast enhanced CT and suggest the hypervascular nature of the metastatic nodule. Such findings can be observed in cases of a metastasis from a sarcoma such as an alveolar soft-part sarcoma or a leiomyosarcoma (Fig. 11 on page 17).

**Pleural Metastases:**

Origin from hematogenous spread to the pleura, but occasionally they may be caused by lymphangitic spread or by direct infiltration of chest wall, abdomen, and mediastinum or from established hepatic metastases. Tumors that spread to the pleura are lung, breast, pancreas, and stomach. Pleural metastases are seen as nodularities, a plaquelike formation on the pleural surface with or without associated pleural effusion. Pleural metastases in contact with the fissures and the diaphragm may be easily detected using
CT scanning (Fig. 12 on page 18). The differential diagnosis includes malignant mesothelioma, invasive thymoma, and lymphoma.

**Tracheal and Endobronchial Metastasis:**

Either from direct endobronchial deposition through aspiration, hematogenous, or lymphatic spread; or by airway invasion of tumor into adjacent lymph nodes/parenchyma. The endobronchial lesion, as well as the consequences (e.g., lobar atelectasis or, less commonly, complete collapse of a unilateral lung) can be identified on CT scans. Tumors such as thyroid, larynx, esophagus, or lung tumors, or by hematogenous spread most commonly colorectal, breast, renal, sarcoma, melanoma, and hematological malignancies such as plasmacytoma and chloroma. Clinical presentation can be hemoptysis and coughing. CT scans shows solitary or multiple masses within the trachea or bronchial tree (Fig. 13 on page 19, Fig. 14 on page 20).

**Lymphadenopathy:**

Spread of a neoplasm through the lymphatics cause the typical pattern of lymphangitic carcinomatosis, most commonly seen in adenocarcinomas, particularly primary tumors of breast, lung, stomach, pancreas, uterus, rectum, or prostate. It occurs from hematogenous spread to the lungs, with subsequent lymphatic invasion or direct lymphatic spread from mediastinal and hilar lymph nodes. Hilar lymphadenopathy and mediastinal lymphadenopathy are present in 20-40% of patients with lymphangitic carcinomatosis, which may be symmetrical or asymmetrical, but there are some exceptional cases with lymphadenopathy without lymphangitic carcinomatosis (Fig. 15 on page 21).

**Metastases after Chemotherapy and Molecular Targeted Therapy:**

Metastases in response to chemotherapy can present with atypical patterns on CT studies. Chemotherapy can induce cavitation, calcification decreased vascularization reflected in changes in attenuation and necrosis, hemorrhage. Even rarer is the development of thin-walled cavities, namely pulmonary lacunae that develop at sites of tumors treated with chemotherapy. (Fig. 16 on page 22, Fig. 17 on page 23)
Fig. 1: Typical pulmonary metastases. 61-year-old man with metastasis from adenocarcinoma of the lung. Axial CT scan shows multiple round nodules of varying sizes, predominantly of peripheral and basal distribution, in both lungs.

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Fig. 2: Lymphangitic carcinomatosis. 57-year-old male with lung adenocarcinoma. Axial CT scan shows smooth interlobar septal thickening (green arrowheads), thickening of the peribronchovascular interstitium (white arrows) and lymphadenopathy (blue arrow).

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Fig. 3: Cavitated metastasis. 86-year-old woman. Axial CT scan shows metastatic nodules and masses from urothelial carcinoma all cavitated and with thickened irregular walls.

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Fig. 4: Cavitating metastasis in a 46-year-old man. Metastasis from squamous cell carcinoma of the tongue. Axial CT shows multiple cavitated masses in the right lung with irregular thickened walls and peripheral areas of consolidation with air bronchogram (green arrowhead). Air-fluid level in one of the cavitated metastasis (white arrowheads).

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**Fig. 5:** Calcified metastasis. 88-year-old woman. Axial CT scan shows metastatic mass from adenocarcinoma of the colon with multiple pleomorphic calcifications.

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**Fig. 6:** Hemorrhagic metastasis. 76-year-old man. Metastasis from adenocarcinoma of the pancreas. Axial CT scan shows multiple metastatic nodules with spiculated borders and peripheral ground glass opacities.

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**Fig. 7:** Air-space pattern of metastasis. 68-year-old man. Metastasis from an adenocarcinoma of the pancreas. Axial CT scan shows patchy and converging consolidations, some poorly marginated with surrounding ground-glass opacity and air bronchogram (arrowhead).

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Fig. 8: Air-space and tree-in-bud pattern of metastasis. 70-years-old woman. Metastasis from endometrioid adenocarcinoma of the ovary. Axial CT scan shows patchy areas of consolidation with air bronchogram (arrowhead); and tree-in-bud pattern that represents endobronchial spread.

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Fig. 9: Tumor Embolism. 49-year-old woman. Transverse contrast-enhanced CT scan obtained with lung window settings shows multifocal areas of peripheral wedge-shaped consolidation and ground-glass opacity in relation with pulmonary infarction due to tumor embolism from endocervical adenocarcinoma.

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Fig. 10: Miliary Pattern of Metastasis. 41-year-old woman. Metastasis from thyroid papillary carcinoma. Axial CT scan shows multiple myliary nodules between 1-4mm.

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Fig. 11: Heterogeneous enhancement and dilated vessels. 52-year-old woman. Metastasis from uterine leiomyosarcoma. A and B) Axial and coronal CT scan show multiple masses with heterogeneous enhancement due to dilated vessels (green arrowheads) and areas of necrosis (white arrows).

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**Fig. 12:** Pleural metastases from adenocarcinoma of the lung. 62-year-old woman. Axial and coronal CT scan shows thickenened visceral pleura with contrast enhancement, and ipsilateral pleural effusion.

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Fig. 13: Endobronchial metastasis. 63-year-old man. Transverse contrast-enhanced CT scan obtained with lung window settings. Endobronchial metastasis from adenocarcinoma of the rectum (blue arrow)

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**Fig. 14:** Endobronchial metastasis. 54-year-old man. Metastasis from hurthle cell carcinoma of thyroid gland. Axial CT scan shows multiple endobronchial metastasis (green arrows). There are also multiple pulmonary nodules and masses, some shows periferal patchy areas of ground glass opacities representing hemorrhage. Bilateral pleural effusion.

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Fig. 15: Masaftatic lymphadenopathy from gastric adenocarcinoma. 63-year-old man. Transverse contrast-enhanced CT shows paratracheal and paraesophageal adenopathy with central necrotic area (white arrows).

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**Fig. 16:** 63-year-old man with metastatic adenocarcinoma of the lung after 8 months of treatment with conventional chemotherapy + bevacizumab. Axial CT scan. A) Before combined treatment. B) After 8 months of combined therapy most of the lesions show cavitation and halo of ground-glass attenuation.

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**Fig. 17:** 75-year-old man with metastatic adenosquamous carcinoma of the lung after 12 months treatment with bevacizumab. Axial CT scan A) Demonstrates multiple metastatic pulmonary nodules in both lungs (white arrowheads). B-C) After 12 months of bevacizumab therapy there has been cavitation in lung metastases (blue arrowheads). Some of the cavitated lesions show a double ring pattern (green arrows).

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Conclusion

It is not uncommon to find thoracic metastasis with atypical radiological manifestations. It is important to know these unusual radiological presentations to distinguish them from other non-malignant lung diseases.
References


