Thoracic and systemic complications in oncologic patients: main imaging findings

Poster No.: P-0096
Congress: ESTI 2019
Type: Educational Poster
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Keywords: Lung, Oncology, Thorax, CT, CT-High Resolution, Chemotherapy, Radiation therapy / Oncology, Radiation effects, Cancer, Drugs / Reactions, Embolism / Thrombosis

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Learning objectives

Identify, discuss, and illustrate some of the major thoracic complications in oncologic patients using CT.
Background

Oncology patients often underwent several medical complications that are a direct or indirect result of the underlying malignant condition. These complications are frequently first identified or clarified on radiologic imaging studies.

Complications may be divided into DIRECT and INDIRECT effects of the tumor. Oncologic emergencies can be also categorized as metabolic, hematologic, and structural conditions. Metabolic and hematologic emergencies are mainly diagnosed on the basis of clinical and laboratory findings. Structural pathologic conditions that result in bleeding, mechanical compression, or obstruction to the hollow organs need imaging studies for diagnosis.

Direct effects include mechanical compression or obstruction of adjacent structures by tumor mass. Indirect complications, include systemic manifestations of disease, like hypercoagulable state, leading to deep venous thrombosis and pulmonary embolism, and an immunocompromised state, leading to various infections, as well as paraneoplastic syndromes with a variety of manifestations. Sometimes even the wrong positioning of devices for the therapy or the therapies themselves to which the patient undergoes can lead to immediate or late complications such as chemotherapy drug toxicity, fibrosis induced by radiation therapy or the extravasation of chemotherapeutic agents in the surrounding tissues; chemotherapy and radiation therapy-related complications can also demonstrate typical imaging features that allow diagnosis.
CT is the imaging examination of choice to investigate most of the thoracic and abdominal emergencies. It is easy to perform rapid, noninvasive, and readily available. Intravenous contrast material is routinely used in most of the patients. Use of multiplanar reconstructions in coronal and sagittal projections yields improved delineation of anatomic details.

In thoracic emergencies we identify:

**Central airway obstruction:** Malignancies involving the tracheobronchial tree, mediastinum, and hilar regions may compress or invade the central airways, resulting in substantial luminal narrowing. Obstruction of the upper airways, including the hypopharynx, larynx, and trachea up to the level of the carina, can cause severe acute respiratory failure, whereas main stem and lobar bronchi obstruction leads to less severe symptoms, such as dyspnea, fever, and cough due to postobstructive pneumonitis (fig. 1). Multidetector CT with coronal and sagittal reformatations can help identify the cause, site, and severity of central airway obstruction and associated lung parenchymal changes.

**Esophagorespiratory fistula:** Abnormal fistulous communication between the esophagus and the trachea, bronchi, and lung parenchyma can develop secondary to both benign and malignant pathologic conditions. Esophagorespiratory fistula is more likely to develop in patients with cancers that involve the middle one-third of the esophagus, those of young age, and those with poorly differentiated and necrotizing cancers that penetrate toward the airways (fig. 2-3). A fistula may develop either secondary to direct tumor invasion into airways or after initial treatment, including irradiation, chemotherapy, laser therapy, and esophageal stent placement (fig. 4). The most frequent site of fistulous communication is esophagotracheal (52%-57% of cases), followed by esophagobronchial (37%-40%), and esophagopulmonary (3%-11%). Multidetector CT with coronal and sagittal reconstructions and virtual CT endoscopy are very useful for estimating the site, number, and extent of fistulae, as well as for assessing the condition of the lung parenchyma. On CT images, a direct fistulous communication between the esophagus and the airways can be identified and is often surrounded by soft-tissue thickening caused by underlying tumor. Multidetector CT is also useful in assessing complications after stent placement, including stent migration, stent fracture, and tracheal stenosis.

**Massive hemoptysis:** Larger tumor size and angioinvasive nature of the mass, destruction of lung parenchymal support for vessels, and increased tumoral neovascularity are the predisposing factors for massive hemoptysis in lung cancer patients. Multidetector CT can help identify the site, cause, and vascular source of bleeding (bronchial vessels vs pulmonary vessels); although rare, CT findings such as active extravasation of contrast material, pseudoaneurysm, and vessel invasion indicate active bleeding.
**Pulmonary Embolism**: the development of deep venous thrombosis and subsequent embolism and tumor embolism are the two important causes of pulmonary emboli in cancer patients. In addition, cancer patients are predisposed to develop deep venous thrombosis because the direct thrombogenic effects of the malignancy, chemotherapy can cause also hypercoagulability (fig. 5-6). Multidetector CT is extremely useful in the detection of pulmonary emboli, and multiplanar reformations can demonstrate the extent of emboli and the continuity of tumor extension from the primary neoplasms.

**Superior vena cava (SVC) syndrome**: Direct invasion or compression by malignancy, with associated intraluminal thrombus formation, is the pathophysiologic basis of narrowing or complete SVC obstruction that subsequently impairs venous drainage from the head, neck, and upper extremities (fig. 7-8). Clinical presentation depends on the speed, severity, and location of the SVC obstruction. Contrast-enhanced multidetector CT of the chest with multiplanar reconstructions is the imaging modality of choice and can help identify the location and severity of the obstruction, superimposed thrombosis, a mediastinal mass or lymphadenopathy, collateral vessels, and associated lung masses.

**Pericardial tamponade**: Pericardial effusion in oncologic patients may develop due to the underlying malignancy, or as a complication of irradiation, or from an opportunistic infection. CT can demonstrate compression and narrowing of the cardiac chambers, either by pericardial effusion or by a mass, findings that indicate the possibility of cardiac tamponade in the appropriate clinical setting. CT findings of high-attenuation pericardial effusions due to hemorrhage or debris and of irregular nodular pericardial thickening with enhancing soft-tissue nodules suggest malignant pericardial effusion. In addition, primary malignancies of the breast and lung and signs of right-sided heart failure can be identified at CT.

**Extrathoracic emergency**

Malignant spinal cord compression (MSCC) is a serious event that has a major impact on patient's life quality. It is the second most common neurological complication of cancer after brain metastasis. The consequences of MSCC can be devastating, leaving the patient with pain, paralysis and incontinence. Most of the affected patients have an advanced cancer with limited survival. Even though it is estimated that up to one third will survive at least a year after MSCC, it is considered a medical emergency that requires immediate diagnostics and treatment. Almost all MSCC are caused by an epidural compression. It can develop in one of the following ways:

1. Vertebral bone metastasis grows into the epidural space and compresses the spinal cord.

2. Para spinal mass grows through the neural foramina.
3. Metastasis in the vertebral body causes its collapse and bone fragments are displaced in the epidural space.

All mechanisms cause venous plexus compression, which leads to oedema of the spinal cord. Oedema and high vascular permeability cause increased pressure to the small arterioles which results in diminished blood flow causing ischemia of the white matter and, if this continues long enough, cord damage. If the time of the compression is short, the effects are reversible. This is supposed to be the explanation for better treatment results of direct decompressive surgery compared to radiotherapy, which produces results only after several days. Most commonly the vertebral body is affected, which results in the anterior compression of the spinal cord. Para vertebral masses growing through foramina are less frequent and often caused by lymphoma, neuroblastoma and sarcoma. In these cases, bone is intact and plain radiography is not useful for the diagnostics. CT have some importance in first diagnosis of MSCC, it provides to the clinician the best information on the three dimensional extension of the tumour also the best diagnostic modality for an essential tool for planning the treatment is magnetic resonance (MRI) (fig. 9-10).

**Iatrogenic complications:** they can develop following the usual methods of treatment of neoplasia such as surgery or chemotherapy (Table 1). Drug-induced pulmonary toxicity (DILD) occurs during, rather than after treatment with the drug, more often via the oral or parenteral route. Less frequently, drugs produce ILD following inhaled or topical administration. However, DI-ILD occurs with normal doses of the drug, rarely, after an overdose. In general, it is difficult to infer the histopathologic background of drug-induced parenchymal reactions from imaging. It is also difficult to separate the drug condition from an opportunistic infection, as both conditions may produce the same pattern of involvement on imaging. HRCT pattern and features of DILD reflects the clinical signs and underlying histopathologic process. The diagnosis of drug-induced ILD (DI-ILD) essentially was based on the temporal association between exposure to the drug and the development of pulmonary infiltrates (fig.11). Also radiotherapy, in the stereotaxic and conformational form determines in late phases three predominant patterns: modified conventional in which a mild, mass-like where fibrosis is present as a consolidation area associated with bronchiectasis at the site of the primitive and scar-like tumor in which opacities of a few cm are highlighted (fig.12). Iatrogenic complications can also develop as a result of placement of central venous catheters used for the administration of chemotherapeutic drugs (fig. 13), some of these drugs may in fact cause direct toxic effects on the lung parenchyma.
**Fig. 1:** Fig. 1: Airway obstruction in 56-year-old man with esophageal cancer. The CT scans (A, C) demonstrate the direct infiltration of the trachea by the neoplasia, causing almost complete obstruction of the tracheal lumen and consequent partial atelectasis of the downstream pulmonary parenchyma (B, D). The patient was treated; a tracheal stent was placed (arrow E).

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**Fig. 2:** Tracheal fistula in a 67-year-old man with central lung cancer. CT scans show the neoplastic tissue (A, D) that causes infiltration of trachea and carina (C) with consequent erosion of the wall and fistulization (B, E, F).

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Fig. 3: Esophagus-tracheal fistula in 70-year-old man with a previous tumor of the esophagogastric junction. The CT scans (A–D) show the wide continuous solution between the esophageous and the tumour with consequent formation of a fluid-air collection.

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**Fig. 4:** Post radiotherapy tracheal fistula in a 52-year-old woman with lung cancer. Axial CT scan shows subcarinal lymphadenopathy (arrow in A). Axial CT image (B) and coronal MPR reconstruction (C), performed after radiotherapy, demonstrate necrosis of the subcarinal lymphadenopathy and the inferior-medial wall's erosion with a little fistula (arrow in B-C)

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**Fig. 5:** 67-year-old man with laryngeal tumor. CT scan (C) shows filling defects in the right upper lobe artery and in the interlobar artery. CT axial images (arrow) showing a partially excavated subpleural consolidation in the lower right lobe referring to infarct (A, B).

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Fig. 6: 33-year-old woman with corioncarcinoma. The CT scans (A, B, C, D) show massive neoplastic thrombosis of the pulmonary veins. Concomit bilateral pleural effusion.

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Fig. 7: 62-year-old male with right upper lobe tumor. Axial CT scans (A, B, C) and the VRT (D) reconstruction show complete infiltration of the superior vena cava that does not appear opacified with consequent development of numerous collateral mediastinal, pericardiophrenic and thoracic wall (D) collateral circles.

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Fig. 8: 42-year-old woman with anterior mediastinal tumor. Axial CT scans and coronal MPR reconstructions (B, C) show infiltration and invasion of the mediastinal vascular structures: SVC appears filiform, irregular, and reduced in size because of infiltration. (A).

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Fig. 9: 72-year-old man with lung cancer. CT scans (A, B, C) demonstrate the presence of neoplastic solid tissue that invades the medullary canal.

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**Fig. 10:** 65-year-old man with lung lobe upper sn. The CT images (A, B) show the presence of solid tissue at the level of the D4 with consequent subversion of the vertebral structure and invasion of the medullary canal.

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**Fig. 11:** Bleomycin-induced NSIP in a 55-year-old man with LNH. CT scans (A, B) demonstrate bilateral reticular opacities and ground glass opacities as well as architectural distortion and bronchiectasis. Centrilobular emphysema is also present.

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**Fig. 12:** 62-year-old man with lung cancer undergoing radiation therapy. The CT scans (A, B), show extensive parenchymal consolidation area in the lower right lobe to refer to post-attinic pneumonia.

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**Fig. 13:** 47-year-old woman with breast cancer. CT MPR (A, B) reconstructions show a fragment of CVC migrated in the descending branch of the left pulmonary artery.

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Table 1: Principal Histopathologic Manifestations and their HRTC patterns

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Conclusion

imaging plays a crucial role in identifying the complications and emergencies that can occur in oncologic patient; the knowledge of the different radiological findings is important in order to improve the patient's management.