EJMA

DOI: 10.14744/ejma.2022.33043
EJMA 2022;2(2):23–29

Invited Review

Thoracic and Abdominal Oncological Emergencies in Radiology

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Abstract

Thoracic and abdominal acute life-threatening oncological emergencies can be secondary either an underlying cancer or a complication of its treatment. Oncological emergencies can be classified in metabolic, hematological or structural. Metabolic and hematological emergencies are diagnosed by clinical and laboratory exams. Indeed, the radiological imaging is essential for the diagnosis of structural oncological emergencies such fistulas, hemoptysis, embolism, superior vena cava syndrome, cardiac tamponade, intraabdominal hemorrhage, bowel obstruction, perforation and ischemia, intussusception and urinary tract obstruction and structural complications of the oncological treatments. Radiologists should be confident with the main findings of structural oncologic emergencies to make an accurate timely diagnosis and to provide appropriate patient care. For this reason, the purpose of this work is to summarize the main clinical and radiological characteristics of thoracic and abdominal structural oncological emergencies.

Keywords: Emergency, oncology, radiological emergencies

Cite This Article: *Fogante M, Marcucci M, Tagliati C. Thoracic and Abdominal Oncological Emergencies in Radiology. EJMA 2022;2(2):23–29.*

Cancer is one of the leading causes of mortality in the world and primary lung cancer represents the most common cause of death for both sexes.[1] Thoracic and abdominal oncological emergency is defined as any acute and potentially life-threatening event, secondary to the direct effects of a cancer or its treatment. These emergencies are destined to increase due to the higher incidence of tumors and the greater patient survival rate. The oncological emergencies can be divided into metabolic, hematological and structural.[2-4]

Metabolic and hematological are represented by hypercalcemia, acute tumor lysis syndrome, hyponatremia, lactic acidosis, febrile neutropenia, hyperviscosity syndrome and disseminated intravascular coagulation, the diagnosis is based on clinical and laboratory analysis and radiological imaging does not provide any help. Indeed, structural oncological emergencies caused by hemorrhage, thrombosis, infiltration, compression or obstruction require imaging exams for diagnosis.[5-8] Radiologists should know the main findings of structural oncologic emergencies to make an accurate timely diagnosis to provide appropriate patient care.

For this reason, the purpose of this work is to summarize the main clinical and radiological characteristics of thoracic and abdominal-pelvic structural oncological emergencies secondary to the cancer or its treatments.

Imaging Approach

Radiography, ultrasound (US) and computed tomography (CT) are the imaging modality that can be used for the evaluation of suspected structural oncological emergencies.[9]

Chest-x-rays (XR), abdominal-XR and abdominal US can be used as the first line modalities in the oncological emergen-

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Submitted Date: April 04, 2022 **Accepted Date:** May 01, 2022 **Available Online Date:** April 28, 2022

cies. CXR can detect lung masses, pleural and pericardial effusions. AXR can detect bowel obstruction and subdiaphragmatic free air. Abdominal US can evaluate abdominal masses and effusion. CT represent the modality of choice to investigate the thoracic and abdominal-pelvic oncological emergencies without and with the use of contrast. It is always available, fast and allows different imaging reformatting and multiplanar reconstructions with a high spatial resolution. CT allow the exact diagnosis of the emergencies and the evaluation of the cancer. Given the different diagnostic imaging options, it is important to select the most appropriate imaging modality to allow for timely diagnosis and treatment.[10-12]

Thoracic Emergencies

Central Airway Obstruction

Central airway obstruction is characterized by the narrowing of the trachea or main bronchi. The main neoplasms that can caused central airway obstruction are lung cancer, lymphoma, mediastinal lymphadenopathy, bronchial carcinoid, endobronchial metastases and primary tracheal tumors, such as chondroma and cystic adenoid carcinoma. The cancer can cause direct obstruction, through intraluminal accretion or invasion of the tracheobronchial tree, or indirect occlusion by external compression involving the mediastinum and the hilar regions. The main symptoms depend on the severity and on the site of the obstruction.[13] The occlusion of the airways up to the level of the carina can cause severe acute respiratory failure, while the obstruction low to the carina leads to symptoms such as dyspnea, fever and cough due to post-obstructive pneumonia. CXR can show enlargement of lung hila or mediastinum, displacement or obstruction of the airways, segmental lung atelectasis or pulmonary consolidation. CT can identify the cause, the location and the severity of central airway obstruction and the associated pulmonary parenchymal changes. The main treatment options are represented by surgical resection, radiotherapy, endobronchial laser ablation, and placement of tracheal stents in inoperable patients.[14, 15]

Esophago-respiratory Fistula

Esophago-respiratory fistula is an anomalous communication between the esophagus and trachea, bronchi and lung parenchyma. The main neoplasms that can cause this fistula are esophageal carcinoma, especially if it is poorly differentiated and concerns the middle-lower of the esophagus, the lung cancer and the lymphoma. A fistula usually develop from the direct tumor invasion into the airways and the most frequent site is the esophago-tracheal, followed by esophago-bronchial and the esophago-pulmonary. Clinically the fistula can cause recurrent ab ingestis pneumonias.[16] CXR may show indirect signs such as mediastinal opacification, lung consolidation and abscess, and pleural effusion. CT is the most useful imaging method to identify the site, number and extension of fistulas and to assess the condition of the lung parenchyma. The indirect sign of the communication between the esophagus and the airways is the thickening of the mediastinal soft tissues. Furthermore, if the contrast media is ingested orally, the presence of this latter in the airways and lung parenchyma suggests the presence of the fistula. The treatment of the fistula is based on stent placement and CT is useful for evaluating subsequent complications such as stent migration, rupture and tracheal stenosis.[17, 18]

Massive Hemoptysis

Massive hemoptysis is defined as an expectoration of 300-600ml of blood in 24 hours. If it is caused by a malignant neoplasm, the mortality rate can be as high as 60%. Bronchogenic carcinoma represents the most common cause of massive hemoptysis in patients over 40 years of age. Other causes are bronchial and endobronchial carcinoids and metastases from colon cancers, breast and kidney. Moreover, fatal bleeding can be caused by invasive angiography aspergillosis and pulmonary aspergillomas in immunocompromised cancer patients. Hemoptysis correlates with the size and angioinvasive nature of the tumor mass and derives from the destruction of the pulmonary parenchymal support for the vessels and the increase of tumor neovascularization. CXR may demonstrate lung parenchyma abnormalities such as lung masses, lung cavity and mediastinal enlargement. CT can show the location, the cause and the vascular source of bleeding (bronchial arterial vs pulmonary arterial) and can demonstrate active bleeding and vessel invasion. CT allows to identify the origin and course of the bronchial artery responsible for hemoptysis, reducing the procedure time and the number of failed procedures. The treatment is represented by embolization of the bronchial arteries and non-bronchial systemic collateral vessels.[19-21]

Pulmonary Embolism

Pulmonary embolism is defined as the occlusion of main pulmonary arteries or their ramifications by emboli. The main tumors responsible of pulmonary embolism origin from breast, lung, prostate, colon, stomach, liver and kidneys. Moreover, the main neoplasms that cause asymptomatic pulmonary embolism are gynecological ones and melanoma. The development of pulmonary embolism in oncological patients can derive from the develop-

ment of deep vein thrombosis or from the tumor itself. Indeed, this latter has a direct thrombogenic effect causing hypercoagulability and can have an indirect effect with small emboli that can trigger the coagulation system, with the development of local thrombus in the lung. This process is more frequent if the cancer is in progression and during chemotherapy. The clinical presentation includes acute dyspnea, chest pain and cardiac problems. [22] CXR is neither sensitive nor specific for a pulmonary embolism. However, the direct signs of pulmonary embolism include an enlarged pulmonary artery, the presence of a peripheral wedge of airspace opacity and pleural effusions. CT is the gold standard imaging method for detecting pulmonary embolism. In addition, CT can detect signs of right ventricular dysfunction and pulmonary artery dilatation secondary to pulmonary hypertension. Moreover, it can show irreversible obstruction characterized by concentric medial hypertrophy and intimal fibrosis of the pulmonary arteries and it can demonstrate the lung involvement secondary to pulmonary embolism. Figure 1 shows a case of a patients with pulmonary embolism secondary to prostate cancer. Treatment of pulmonary embolism involves fibrinolysis, although interventions such as aspiration thrombectomy or thrombus fragmentation are useful to reduce right ventricular afterload in massive pulmonary embolism when fibrinolysis is contraindicated or in unstable patients.[23, 24]

Superior Vena Cava Syndrome

Superior vena cava syndrome is defined as the narrowing and increment of the pression in superior vena cava. The most common oncological malignancies responsible for this syndrome are the lung cancer and lymphoma. Other cancers that can cause this syndrome are metastatic lymph nodes (commonly from breast cancer), germ cell and malignant thymomas. The pathophysiological basis are secondary to direct invasion or compression of the superior vena cava by the malignant tumor, which impairs venous drainage of head, neck and upper extremities. Clinical presentation depends on speed, severity, the location of the obstruction and the presence of adequate collateral circulation. The most severity symptoms are secondary to cerebral edema and laryngeal and requiring emergency treatment. CXR may show enlargement of the superior mediastinum and right hilar ectasia and the presence of a mediastinal mass. CT can identify cause, the location and severity of the obstruction, the presence of superimposed thrombosis, mediastinal mass or lymphadenopathy, and collateral vessels. Angioplasty with or without stent placement is the treatment of choice in patients with life-threatening symptoms.[25, 26]

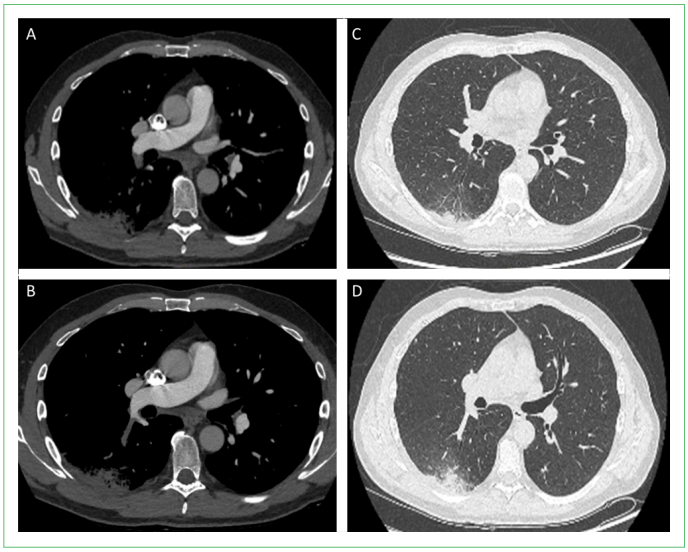

Figure 1. A 50-year-old-male patient with with secondarisms to prostate cancer. Image **(a, b)** show the presence of pulmonary embolism in a right lobar artery for the inferior lung lobe. Images **(c, d)** show the infarct lung in the corresponding lung segment.

Cardiac tamponade

Cardiac tamponade is defined as the accumulation of fluid, pus, blood, gas, or benign or malignant neoplastic tissue within the pericardial cavity, which results in impaired cardiac output. The main oncological cancer that can cause CT are the metastatic lesions from breast cancer, lung cancer and mediastinal lymphoma. Effusion occurs for tumor bleeding, pericardial lymphatic obstruction and the altered vascular permeability. Accumulation of pericardial fluid and a consequent increase in intrapericardial pressure can cause impaired cardiac filling and consequent hemodynamic compromise. The risk of heart failure depends on the rate at which the pericardial effusion occurs. Moreover, rarely, primary pericardial tumors such as rhabdomyosarcoma and mesothelioma can compress the heart chambers, resulting in cardiac tamponade. The most common symptoms are dyspnea, acute circulatory collapse, chest pain and tachycardia. CXR include signs such as cardiomegaly with a "water bottle" cardiac silhouette, mediastinal enlargement and hilar masses. Abdominal US allows direct visualization of the pericardial effusion with the subxiphoid window. CT can show the pericardial effusion with evaluation of the hemorrhagic component. Furthermore, it allows the diagnosis of nodular pericardial masses or thickenings, the evaluation of compression and narrowing of the heart chambers in the context of possible cardiac tamponade. Pericardiocentesis with or without drain placement is the life-saving treatment in acute cardiac tamponade.[27]

Abdominal Emergencies

Hemorrhage

Intra-abdominal hemorrhage is defined as the presence of blood in the abdomen, and it represents a rare but potentially fatal complication. Hypervascular cancers, such as hepatocellular carcinoma, renal cell carcinoma and melanoma are the main causes of spontaneous hemoperitoneum. Furthermore, splenic lymphoma can cause splenic rupture and severe bleeding, particularly in the case of large masses, with a peripheral or subcapsular location. The main pathophysiological factors of spontaneous bleeding are the tumor vascular invasion, the presence of tumor neoangiogenesis with poorly formed new vessels, the increase of the intratumoral pressure due to venous congestion or lack of self-regulatory mechanisms.[28] US is the first imaging modality to identify the presence of blood in the abdomen. Non-contrast CT allows to identify hemoperitoneum, characterized by attenuation of about 30-45 HU due to the presence of non-coagulated extravascular blood. Instead, the presence of coagulated blood with attenuation between 45-70 HU, known as the "sentinel clot", can indicate the source of bleeding. CT with contrast media allows the direct visualization of the site and the grade of the bleeding within the neoplasm and in peritumor region. Angiography allows to confirm the diagnosis of bleeding and with the surgery it represents a possible treatment for the embolization.[29, 30]

Intestinal Emergencies

The most common intestinal emergencies in cancer patients are obstruction, perforation, ischemia and intussusception. Bowel obstruction is defined as a partial or complete block of the intestine. It is secondary frequently to gastrointestinal and gynecological neoplasms or metastases from melanoma and breast cancer. The obstruction may derive by the tumor growth in the intestinal wall with reduced intestinal motility, such as plastic linitis, or can be secondary to the endoluminal tumor growth or external tumor compression. Abdominal-XR allows to identify the dilated loops with gas-fluid levels. CT can show the location, the severity and the cause of the obstruction. Furthermore, CT allows the tumor staging and the choice of the correct treatment plan. The main treatment is represented by surgery, however in inoperable patients, pharmacological palliation or the placement of a self-expanding metal stent, are need.[31] Figure 2 shows a case of a patients with bowel obstruction secondary to a duodenal cancer. Intestinal perforation is defined as a solution of continuity in the intestinal wall. The colorectal cancer and gastrointestinal lymphoma are the tumors that most frequently can

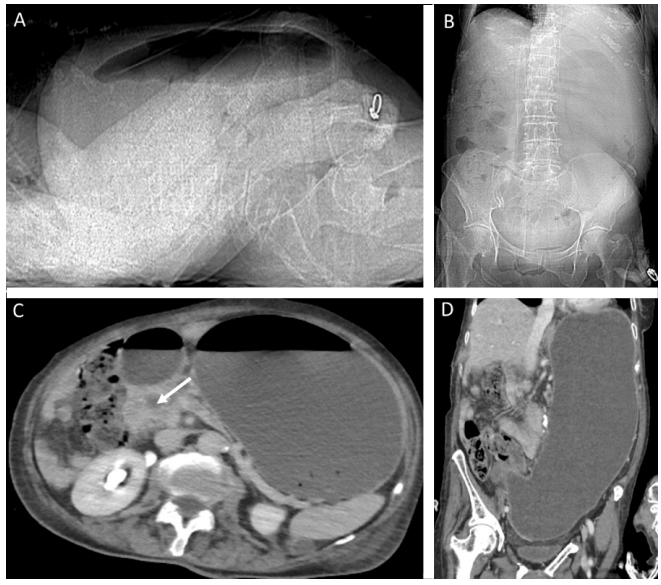

Figure 2. A 50-year-old-female patient with duodenal cancer. Image **(a, b)** show the abdominal distention and the gas-fluid level in abdominal XR. Image **(c, d)** confirm the distention of the stomach with an obstructive duodenal cancer (white arrow).

undergo spontaneous perforation, particularly after systemic chemotherapy. The perforation can be secondary to the wall erosion and to the higher intraluminal pressure which causes a weakening and a breakage of the wall. Abdominal-XR allows to detect free abdominal air. CT allows detection of pneumoperitoneum, site and extent of perforation and any complications, such as entero-enteric fistula. Intestinal ischemia characterized by the reduction of arterial flow or reduction of venous drainage, is frequently with colon cancer.[32] Bowel ischemia can occur in patients with mesenteric root metastases, such as metastases from colon cancer, breast cancer, ovary lung cancer, lung cancer or in patients with pancreatic adenocarcinoma invading the mesenteric root with secondary ischemia of the small intestine to the compression and invasion of the superior vein and mesenteric artery. Abdominal-XR can identify dilated bowel loops. CT allows to identify the intestinal wall, that is thin in the arterial ischemia and thick in venous ischemia, the presence of intestinal pneumatosis, the presence of air in the portal vessels and the state of the mesenteric vessels. Figure 3 shows a case of a patient with bowel ischemia secondary to superior mesenteric vein thrombosis from colon cancer. Intussusception is defined when one segment of bowel is pulled into itself or a neighboring loop of the bowel by peristalsis. About half of the intussusceptions in adults are secondary to both primary and secondary intestinal wall tumors involving the small intestine and the colon which they can act as lead points. The most frequent tumors are intestinal lymphoma, gastrointestinal

Figure 3. A 63-year-old-male patient with colon cancer. Image **(a, b)** show the presence of venous intestinal ischemia, with the thickening of intestinal wall, secondary to the superior mesenteric vein thrombosis (white arrow) has shown in image **(c)**.

cancer and metastatic disease. CT can show a "bowel-within-bowel" configuration, in which the layers of the bowel are duplicated forming concentric rings with or without incorporation of fat and adjacent vessels. Figure 4 shows a case of a patient with bowel intussusception secondary to intestinal lymphoma. In adults, a laparotomy is usually required, especially as in most cases a lead point requiring treatment is present.[33, 34]

Urinary Tract Obstruction

Urinary tract obstruction occurs in approximately 25% of patients with pelvic and retroperitoneal cancer. The main causes are prostate cancer, cervical cancer and bladder cancer. Lymphomas, sarcomas and metastatic lymphadenopathy from carcinomas of the cervix, bladder, prostate, rectum, ovary and testicles, can cause unilateral or bilateral ureteral obstruction if the mass is large. The pathophysiological bases are extramural compression or direct tumor invasion. The distal third of the ureters is the frequent site of obstruction.

Figure 4. A 61-year-old-male patient with intestinal lymphoma. Image **(a, b, c)** show a colon-rectal intussusception secondary to intestinal lymphoma.

Abdominal US allows to identify hydroureteronephrosis. CT with urographic phase can confirm the suspected obstruction and can detect the cause. In addition, the blocked kidney, compared to the contralateral kidney, demonstrates hypoperfusion during the corticomedullary phase if compared with the contralateral kidney. Surgery is the treatment of choice, however in inoperable patients the nephrostomy or ureteral stent placement for relieving the urinary tract obstruction are need.[35-38] Figure 5 shows a case of a patient with urinary tract obstruction with prostate cancer.

Treatment-related Emergencies

Surgery, chemotherapy with the positioning of CVC and radiotherapy and are the treatments commonly used in cancer. The main complications after surgery are represented by the leak of the anastomosis, the abscess formation and hemorrhages. CT can detect these complications. Figure 6

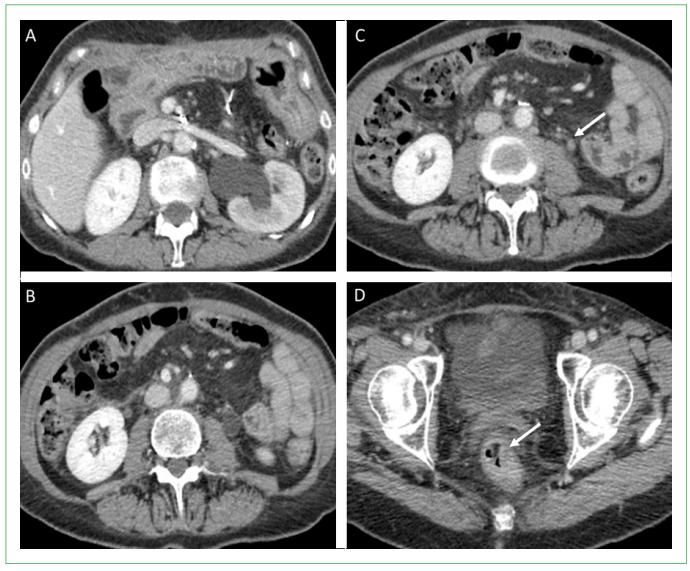

Figure 5. A 62-year-old-male patient with rectal cancer. Image **(a, b)** show the dilatation of the upper part of the left urinary tract due to the presence of a metastatic node (white arrow) that cause an external compression of the ureter has shown in image **(c)**. Image **(d)** demonstrates the primary rectal tumor.

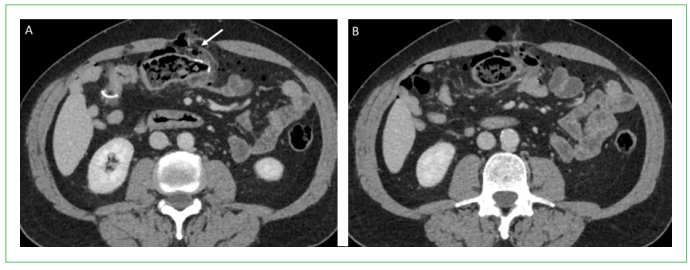

Figure 6. A 70-year-old-male patient with previous colon cancer. Image **(a, b)** demonstrate the leak (white arrow) of the intestinal anastomosis after a surgical asportation of colon cancer. The images evidence the presence of diffuse pneumoperitoneum.

shows a case of a patient with leak of anastomosis secondary to the surgical asportation of colon cancer.

Chemotherapy is commonly used in cancer both as a neoadjuvant therapy, as an adjuvant therapy and as a palliative therapy. Cisplatin, a cytotoxic drug used in the treatment of testicle, head and neck, ovarian and lung carcinomas, can cause thromboembolism and arterial thrombosis. Bevacizumab, a monoclonal antibody aimed at vascular endothelial growth factor, is used for the treatment of metastatic colorectal, ovarian and breast cancers and can cause spontaneous gastrointestinal perforation. Serious and radiologically detectable complications of CVC placement include arterial injury, pneumothorax, and venous thrombosis. Radiotherapy can cause acute enteritis and a shrinkage of the distal third of the ureters.[39-42]

Conclusion

Thoracic and abdominal acute emergencies in oncological patients can be caused by the cancer or its treatments. These emergencies are rare but often life-threatening. In the structural emergencies the radiologist have a decisive role in the prompt diagnosis and in the directing of the appropriate treatment. For these reasons, every radiologist who works in the emergency department, should be confident with the main findings of oncological emergencies.

Disclosures

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

Authorship Contributions: Concept – M.F.; Design – M.F.; Supervision – M.F., M.M., C.T.; Materials – M.F.; Data collection and/ or processing – M.F.; Analysis and/or interpretation – M.F.; Literature search – M.F.; Writing – M.F.; Critical review – M.F., M.M., C.T.

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