Nonthrombotic pulmonary arterial embolism: radiological findings

Poster No.: C-0274
Congress: ECR 2013
Type: Educational Exhibit
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Keywords: Thorax, CT, Radiografía simple
DOI: 10.1594/ecr2013/C-0274

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Learning objectives

• Learning Objective Describe the characteristics of the thrombotic pulmonary embolism images.
• Correlate typical clinical symptoms with the characteristics of the images of the thrombotic pulmonary embolism.

Background

Non-thrombotic pulmonary embolisms are less common than embolisms of thromboembolic origin. Still, they are often associated with specific imaging findings with clinical features.

Imaging findings OR Procedure details

Non-thrombotic pulmonary embolisms include a wide variety of types:

SEPTIC PULMONARY EMBOLISM

Septic embolism occurs with the arrival of infected products to the lung, with microorganisms that are typically bacteria, and less frequently fungi or parasites. The most common predisposing factors are the tricuspid valve endocarditis in patients who may or may not be addicted to drugs as a result of maternal addiction, alcoholism, skin infections and immunosuppressive states (especially lymphoma). Septic emboli can be detected in patients who are carriers of catheters or infected pacemaker leads.

In a chest x-ray, there typically appear bilateral nodules of various sizes and stages of cavitation (Fig. 1 and 2). With time, the lesions may progress to form wedge-shaped dense areas with a peripheral base. Septic emboli are frequently complicated by empyema.

The CT findings consist of nodules with different degrees of cavitation and areas of high subpleural and cuneiform attenuation. The nodules tend to be more numerous in the lower lobes (Fig. 3). In many cases, a vessel may directly reach nodules (evidence of nutrient vessel).
HYDATID EMBOLISM

Pulmonary embolism is a complication of cardiac or hepatic echinococcosis that occurs when the liver or abdominal cysts burst in the hepatic veins or inferior vena cava, and those of cardiac origin do it in the right chambers. Hydatid emboli can cause acute respiratory failure, subacute pulmonary hypertension, or produce chronic pulmonary hypertension.

Both CT angiography and MR angiography show occlusion of the pulmonary arteries and their branches by cystic lesions.

FATTY EMBOLISM

The most common cause is the fracture of long bones and the pelvis. The incidence as a complication of isolated fractures complicating long bone is estimated between 0.5 - 2%, but can reach 10% in multiple fractures of long bones and pelvis (Fig. 4). Other etiologies include total hip or knee arthroplasia, lymphangiography, trauma affecting fatty organs (liver), median sternotomy, closed cardiac massage, blood transfusion, bone marrow transplant, decompression syndrome, septic shock, acute pancreatitis, sickle cell anaemia, burns, cardiopulmonary bypass, lipid infusion and liposuction.

Risk factors for its development are: absence of immobilization of the fracture or inadequate immobilization, closed long bone fractures and multiple fractures with deferred immobilization, and they favour the appearance of the concomitant haemorrhage and shock.

Once the medullary fat reaches the pulmonary circulation, there is a release of free fatty acids due to pulmonary lipase, these acids are toxic and cause endothelial damage responsible for the increased vascular permeability. The classic triad of presentation is the onset of dyspnoea, mental confusion and petechiae. Most often, the symptoms are present within 72 hours of injury (60% in the first 24 hours). Chest x-rays show large areas of homogeneous and heterogeneous increased attenuation between 12-24 hours after onset of symptoms, unlike pulmonary contusion (Fig.5). In the CT, areas of focal consolidation or ground-glass opacity and lymph nodes in the upper lobes are discernible (Fig. 6). The resolution of the opacities can be seen in an x-ray or CT scan 7 to 15 days from the onset of the symptoms (Fig. 7).

AMNIOTIC FLUID EMBOLISM
This occurs when the amniotic fluid enters the uterine veins during labour or manipulation of the placenta. Areas of increased bilateral homogeneous and heterogeneous attenuation which are indistinguishable from other causes of acute pulmonary oedema. The differential diagnosis has to be made with diffuse pulmonary haemorrhaging and aspiration pneumonias.

TUMOR EMBOLISM

Detection is much more common in autopsies (26%) than previous to death. Extrapulmonary malignancies producing carcinoma tumour emboli are: hepatocellular, breast, kidney, stomach, prostate and choriocarcinoma.

X-ray findings are often minimal and nonspecific, making diagnosis difficult radiologically. Occasionally, areas of increased heterogeneous and diffuse attenuation can be seen on the x-ray, findings that may mimic carcinomatous lymphangitis.

The most important CT finding is the tree-in-bud pattern (Fig. 8). There are two different pathogenic mechanisms involved in producing the pattern. The first is the filling of centrilobular arteries with tumour cells. The second is the thrombotic microangiopathies characterized by intimal hyperplasia in the small pulmonary arteries caused or initiated by microemboli tumours. The patients presented with dyspnoea, cough and signs of hypoxia and pulmonary hypertension.

GASEOUS EMBOLISM

The rupture of an organ or penetrating trauma that also affects the systemic venous circulation can cause embolism. Iatrogenic causes include: barotrauma, hemodialysis and central venous catheters. Small amounts of air can be found in 23% of patients after the administration of CT contrast material (Fig. 9). Mortality depends on the amount and speed of air entering.

On chest x-rays, there may appear radiolucent areas in the right heart, the pulmonary arteries and suprahepatic veins. There are also signs of pulmonary oligohemia, pulmonary oedema and right heart insufficiency.

In the CT, small amounts of air in the systemic veins, right heart and main pulmonary arteries can be seen.
CEMENT EMBOLISM (POLYMETHYL METHACRYLATE)

Although percutaneous vertebroplasty is a very safe procedure, there is a potential risk of pulmonary embolism via the external vertebral venous plexus. Both CT and x-ray show areas of increased tubular attenuation delineating the pulmonary arteries. By CT it is possible to detect perivertebral leaks.

FOREIGN BODY EMBOLISM

When a foreign body is fragmented, some of the pieces can become emboli may travel arterially or venously and become impacted at a distance. Mortality depends on the location, the processing time and the number of emboli. Cardiovascular lesions are common, but other complications such as perforation, thrombosis and infection are also possible. The two most common places where there is a catheter embolism are basilica veins and pulmonary arteries. The chest x-ray reveals a catheter fragment in an unusual location, a finding that can be confirmed by both CT and angiography (Fig 10 and 11).

TALC EMBOLISM (TALCOSIS)

The talc may be an excipient in intravenous drug administration. Chest x-rays findings go from numerous miliary nodules to extensive areas of increased attenuation resembling progressive massive fibrosis seen in patients with silicosis. There are also signs of pulmonary hypertension. Using CT, it has been described as a rare cause of tree-in-bud pattern.

IODIZED OIL EMBOLISM

Described in patients who had undergone lymphangiography. X-rays performed immediately after the procedure showed small areas of increased opacity.

Images for this section:
Fig. 1: Figure 1: 10 years-old patient without known risk factors. Anteroposterior x-ray of left shoulder: in the medial diaphyseal humeral and the medial sides, one can see osteolysis with a cortical reaction (white arrow), as well as lytic foci in the proximal humeral metaphysis, findings for osteomyelitis. In the left half-lung, a cavitated nodule (black arrow) can be observed in relation to a septic embolism focus.
Fig. 2: Figure 2: 35 year-old patient with a history of IDU. Posteroanterior chest x-ray. Multiple bilateral nodules are observed, predominantly in the lower lobes of different sizes and stages of cavitation. Findings which correspond to a septic embolism.
Fig. 3: 41 year-old immunocompromised patient. Chest CT after administration of IVC: bilateral nodules with different degrees of cavitation are identifiable, as well as bilateral pleural effusion with right predominance. Findings related to septic embolism.
**Fig. 4:** Figure 4: 44 year-old patient presented multiple lower limb fractures (tibia and fibula in both legs) after traffic accident.

![Image of chest x-ray showing diffuse areas of ground-glass opacity in both hemithoraxes.]

**Fig. 5:** Fig 5: Same patient as in Fig. 4, 48 hours later. Anteroposterior chest x-ray: diffuse areas of ground-glass opacity in both hemithoraxes.
**Fig. 6:** Same patient as in Fig. 4 and 5. Chest CT after administration of IVC: pulmonary parenchyma are identified in patchy areas of ground-glass opacity as well as centrilobular nodular opacities predominating in the upper lobes; also observable is a bilateral, though predominantly right lung, pleural effusion with atelectasis of adjacent parenchyma.
**Fig. 7:** Fig 7: Same patient as in Fig. 4, 5 and 6. Anteroposterior chest x-ray performed eight days after the one in Figure 5: resolution of bilateral ground-glass opacities.
**Fig. 8:** Figure 8: A 45 year-old patient with a tumor embolism secondary to ring cell gastric tumor. Chest CT after administration of IVC: bilateral pulmonary involvement is seen consisting of multiple small centrilobular nodules of soft-tissue attenuation connected to branching linear structures, the typical tree-in-bud pattern.
**Fig. 9:** Figure 9: 37 year-old patient. Chest CT after administration of IVC: a small amount of air in the main pulmonary artery as an incidental finding can be seen.
**Fig. 10:** PA and lateral chest x-ray. There is a fragment of Port-a-Cath in the topography of the right pulmonary artery and interlobar artery.

**Fig. 11:** Chest CT. Axial slices in which there is a fragment of Port-a-Cath in the right pulmonary artery, the interlobar artery and the right inferior interlobular artery.
Conclusion

Knowledge of the various imaging findings characteristic of different types of pulmonary thrombotic emboli should facilitate a quick and effective diagnosis. The CT plays an important role in the detection of embolic material, in the identification of the source with high accuracy, and therefore a proper treatment can be initiated early.

References


Personal Information