Various Etiologies of Pulmonary Infarction: Beyond the Usual Suspects

Exhibit Category: Systemic and pulmonary vasculature

Boda Nam, Tae Jung Kim, Kyung Soo Lee, Tae Sung Kim, Joungho Han, Myung Jin Chung

Department of Radiology
Samsung Medical Center
Sungkyunkwan University School of Medicine
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Learning Objective/Outcomes

- Understand the anatomy and physiology of the dual pulmonary blood circulation and the pathophysiology of pulmonary infarction

- Describe the various conditions resulting in pulmonary infarction with characteristic imaging findings at chest CT
  - Pulmonary arterial thromboembolism
  - Rare tumorous or infectious conditions

- Discuss the key imaging features of pulmonary infarction
  - Central lucency as a differential diagnosis from pneumonic consolidation
Contents

• Anatomy/pathophysiology of dual blood supply of the lung

• Pulmonary infarction
  • Clinical manifestation
  • Key imaging features
  • Serial image changes
  • Common cause
    ✓ Pulmonary arterial thromboembolism
  • Other causes
    ✓ Tumorous condition: lung cancer, pulmonary vessel sarcoma, metastasis
    ✓ Infection: invasive fungus, bacteria
    ✓ Post-procedure: venous infarction related radiofrequency ablation, lung torsion after pulmonary resection
    ✓ Others: hypereosinophilic syndrome
**Dual Pulmonary Circulation**

**Primary pulmonary circulation**
- Entire venous return of the body → Flowing forward from the main pulmonary artery → ramifying throughout pulmonary interstitium & airway → pulmonary veins → Left atrium

**Secondary bronchial circulation**
- Majority of oxygen supply to lung parenchyma
- Arise from thoracic aorta or intercostal arteries
- Supply esophagus, trachea, visceral pleura, LNs, airways, bronchovascular and neural bundles, vasa vasora
Pulmonary Infarction

- Minority of the patients with PE – 10~15%
- Occlusion of distal medium- or small-sized artery
  > Central pulmonary artery
- Reperfusion by bronchial circulation, combined with locally increased vascular permeability → Intraalveolar extravasation of blood cells → **Pulmonary hemorrhage**
- **Pulmonary hemorrhage** → Progression into **infarction**
  - Underlying malignancy
  - High embolic burden
  - Diminished bronchial flow (shock, hypotension)
  - Vasodilator use
  - Interstitial edema (Heart failure)
Pulmonary Infarction

- **Respiratory symptoms**
  - Pleuritic chest pain – m/c manifestation
  - Hemoptysis, blood tinged sputum
  - Hemorrhagic pleural effusion
  - Dyspnea, tachypnea

- **Other symptoms**
  - Sweating
  - Syncope

- **Risk factor of pulmonary thromboembolism**
  - Oral contraceptive use
  - Recent pregnancy/termination of pregnancy
  - Drug history
  - Family history
Pulmonary Infarction

M/70 Blood tinged sputum (for a week)

Key imaging features

★ Key imaging feature of pulmonary infarction ★
Central lucency in peripheral consolidation

Contrast-enhanced CT shows central lucency (arrows) in right lower lobe consolidation on both mediastinal and lung window setting images which is a characteristic finding suggesting pulmonary infarction
Serial change of pulmonary infarction on CXR

Melted ice cube sign

Serial chest radiographs show focal increased opacity in the right middle lung zone (pulmonary infarction with hemorrhage) resolves by maintaining their shape, the so called “melting ice cube sign”
Contrast-enhanced CT shows acute pulmonary thromboembolism in the right pulmonary arteries (white arrows) and peripheral wedge shaped consolidation in the right middle lobe (red arrow), typical finding of pulmonary infarction. Follow-up CT scans after a month and 5 months show decreased in extent and finally almost resolution.
Pulmonary Thromboembolism with Infarction

M/60 Blood tinged sputum

Contrast-enhanced CT shows intraluminal low density filling defect, which has acute angle with arterial wall in the left lower lobar pulmonary artery (white arrow), suggesting acute pulmonary thromboembolism and findings of pulmonary infarction with hemorrhage in the left lung (red arrows).
Unsuspected Diagnosis in Non-contrast CT: Pulmonary Embolism and Infarction

Pulmonary embolism and infarction on non-contrast CT

Non-contrast CT shows peripheral wedge shaped triangular opacity with central lucency (white arrow), which suggests the possibility of pulmonary infarction. Diagnosis of pulmonary thromboembolism is limited due to non-contrast scan, so contrast-enhanced CT for pulmonary embolism should be recommend in patients with central lucency and relevant clinical symptoms.

M/81 Right flank pain
Unsuspected Diagnosis in Non-contrast CT: Pulmonary Embolism and Infarction

M/81 Right flank pain

Follow-up contrast-enhanced CT shows peripheral consolidation with central lucency (white arrow), finding of pulmonary infarction and reveals acute pulmonary thromboembolism in the right lower pulmonary artery (red arrow) and deep vein thrombosis in the left common femoral vein (yellow arrow).
Pulmonary Thromboembolism on CT

- **Diagnostic criteria for acute pulmonary thromboembolism**
  - **Arterial occlusion** with failure to enhance the entire lumen
  - A partial filling defect surrounded by contrast material
    - ✓ “Polo mint” sign on axial image
    - ✓ “Railway track” sign on longitudinal image
  - A peripheral intraluminal filling defect – acute angles with arterial wall

- **Right-sided heart failure**
  - Right ventricular dilatation (RV cavity > LV cavity)
  - Deviation of interventricular septum toward the LV
Lung cancer with Pulmonary Infarction

M/60 Known lung cancer (ADC)

Fever

Lung cancer with direct invasion of pulmonary artery and infarction

Contrast-enhanced CT shows irregular enhancing wall thickening of left main bronchus and lymph node enlargement at aortopulmonary window with direct invasion into left main pulmonary artery (white arrow) and findings of multifocal areas of pulmonary infarction with hemorrhage in the left lung (red arrows)
Pulmonary Vessel Sarcoma with Pulmonary Infarction

M/54 Cough (for 3 months)

Contrast-enhanced CT shows soft-tissue mass obliterating right inferior pulmonary vein just abutting the right lower cardiac margin (white arrow) and findings of venous infarction in the right lower lobe (red arrows). Hypermetabolism is seen (yellow arrow) at the corresponding site on PET-CT scan.

Pulmonary vein sarcoma with venous infarction
Pulmonary Vessel Sarcoma with Pulmonary Infarction

- Arising from the mesenchymal cells of the intima
- Misdiagnosed as **pulmonary thromboembolism**

**CT finding favoring pulmonary artery sarcoma**
- Expansion of the involved arteries
- Extraluminal tumor extension
- Unilaterality of low density filling defect
- Hilar mass or hilar infiltrative lesion
- Intravascular soft-tissue mass with decreased or absent perfusion on ventilation/perfusion study
- Multiple metastatic pulmonary nodules or other distant metastases

**FDG-PET CT scan**
- Positive FDG uptake (cf., negative FDG uptake in blood thrombi)
Invasive Fungal Pneumonia with Infarction

F/60 Fever

Invasive aspergillosis with pulmonary infarction

Non-enhanced CT shows reversed halo sign (arrows), representing ischemia: Central ground-glass opacity is due to infarction with preserved air spaces, whereas the rim of consolidation is due to dense inflammation, or hemorrhage within the alveolar air spaces.
Invasive Fungal Pneumonia with Infarction

- **Reversed halo sign**

  : COP, bacterial pneumonia, mucormycosis, paracoccidioidomycosis, tuberculosis, sarcoidosis, radiofrequency ablation, Wegener granulomatosis, tumor, and **pulmonary infarctions**

- Central ground-glass area
  - Central infarction - extensively occlusion of pulmonary arteries & veins by thrombi containing hyphae
  - Alveolar septal inflammation

- Peripheral dense consolidation
  - Inflammation, massive hemorrhage, and fibrinous exudates
  - Intra-alveolar infiltration
Klebsiella Pneumonia with Infarction

M/81 Fever
Underlying DM

Contrast-enhanced CT shows a probable septic pulmonary embolism (white arrow) and focal consolidation with decreased enhancement and internal bubble density (red arrow) in the both lower lobes, suggesting pulmonary infarction.
Septic Pulmonary Embolism

- **Non-thrombotic pulmonary embolism**
  - Thrombus containing microorganism, causing inflammatory reaction

- **Cause** *pulmonary infarction* and *metastatic abscesses*

- **Typical CT finding**
  - Peripheral nodules with or without cavitation
  - Feeding vessel sign
  - Wedge-shaped peripheral lesions abutting the pleura
Pulmonary Vein Stenosis after Catheter Ablation for Atrial Fibrillation

M/58 Chest pain, blood tinged sputum
History of RF ablation

Contrast-enhanced CT shows intraluminal low density filling defects of the left superior pulmonary vein (white arrows), suggesting pulmonary vein stenosis with thrombosis and poorly defined ground-glass opacity lesions in the left upper lobe (red arrows) are probably due to venous infarction.
Pulmonary Vein stenosis after Catheter Ablation for Atrial Fibrillation

- 1-3%, up to 20% of cases of PVS in catheter ablation

**Mechanism**
- Scarring & contraction of venous wall
- Result of thermal injury

**Symptoms**
- Asymptomatic (m/c)
- Dyspnea on exertion, orthopnea, cough, hemoptysis, recurrent pulmonary infection

**Treatment**
- Surgical excision of localized stenosis
- Re-implantation of PVs with direct anastomosis to the LAA
- Balloon angioplasty
- Endovascular stenting
Lung Torsion after Pulmonary Resection

M/54 RUL lobectomy for squamous cell carcinoma

Rare cause Post-procedure
Lung Torsion after Pulmonary Resection

M/54 RUL lobectomy for squamous cell carcinoma

Postop. non-contrast CT shows focal consolidation with central lucency at the medial aspect of right middle lobe on mediastinal (white arrow) and lung (red arrow) window setting images, suggesting a kind of lung infarction due to right middle lobar torsion.

RML torsion after RUL lobectomy

POD#2
Lung Torsion after Pulmonary Resection

Intraoperative thoracoscopy

- 180° clockwise rotation of RML

- Infarction of RML medial segment
Lung Torsion after Pulmonary Resection

- **Definition**
  - Rotation of bronchovascular pedicles with consequent airway & vascular obstruction
  - Interstitial edema & hemorrhagic infarction

- **Presentation**
  - Incidence: 0.09-0.04%
  - Rapid progression of shock, sepsis
  - RML after RUL lobectomy (70%)

- **CT finding**
  - Tapered obliteration of the proximal pulmonary artery and bronchus
  - Torsed lobe: consolidation, poor enhancement, GGO, septal thickening, central lucency (infarction)
Hypereosinophilic Syndrome with Infarction

M/34 Pleuritic chest pain
Eosinophil 65%

Hypereosinophilic syndrome and pulmonary embolism with infarction

Contrast-enhanced CT shows pulmonary thromboembolism in the right middle lobar pulmonary artery (white arrows) and findings of pulmonary infarctions in the right middle lobe (red arrows)
Hypereosinophilic Syndrome with Infarction

- **Diagnostic criteria**
  1) Persistent eosinophilia $\geq 1.5 \times 10^9$/L
  2) Lack of evidence for parasitic, allergic or other known causes of eosinophilia
  3) Signs and symptoms of eosinophil-mediated organ dysfunction

- **Pulmonary involvement** - 40~60%
  - Chronic, persistent, non-productive cough
  - Secondary to congestive heart failure, infiltration of eosinophils in lung, pulmonary emboli originating from ventricular thrombi
  - Rare recurrent pulmonary thromboembolism, leading to chronic pulmonary hypertension
  - **Image finding**: nodules, ground-glass opacities, interlobular septal thickening, pleural effusion
Pulmonary infarction: Summary

- **Clinical manifestation**
  - Chest pain (often pleuritic), flank pain
  - Blood tinged sputum, hemoptysis

- **Key imaging feature**
  - Central lucency in peripheral consolidation
  - Note central lucency especially in non-contrast CT

- **Variable cause of pulmonary infarction**
  - Arterial thromboembolism – most common
  - Rare causes
    - **Tumor** : lung cancer, pulmonary vessel sarcoma
    - **Infection** : fungus, bacteria, septic embolism
    - **Post-procedure** : venous infarction related RF ablation, lung torsion after pulmonary resection
    - **Others** : hypereosinophilic syndrome
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Thank you!

Contact information:
 Tae Jung Kim
 Department of Radiology
 Samsung Medical Center
 Sungkyunkwan University School of Medicine
 Seoul 06351 Korea
 Tel) 822-3410-2511
 FAX) 822-341-2559
 E-mail) taejung.kim1@gmail.com