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Radiological Features of Lung Abscess

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ABTRACT

Lung abscess is still a significant cause of morbidity and mortality. The worldwide mortality rate ranges from 15% to 20%. Radiologically, lung abscesses appear as single or multiple cavities that can mimic many other pulmonary pathological processes which pose a challenge for radiologists to understand this disease. Failure in early diagnosis and treatment can lead to a poor prognosis. Radiological examinations such as conventional radiography, computed tomography (CT) scan, ultrasonography (US and magnetic resonance imaging are available in establishing the diagnosis of lung abscess where CT scan has the best diagnostic performance. The use of appropriate radiological modalities is expected to help rule out many other differential diagnoses, so that an accurate diagnosis can be made.

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1. INTRODUCTION

Lung abscess is a pulmonary lesion in the form of central suppuration and necrosis of the lung parenchyma tissue which causes damage to the lung parenchyma and the formation of one or more large cavities. Epidemiologically, lung abscess is still a significant cause of morbidity and mortality. The mortality rate from lung abscess ranges from 15-20%, but has decreased compared to the pre-antibiotic era where the mortality rate from lung abscess ranges from 30-40%. The incidence of lung abscess has decreased over the last 30 years due to advances in medical science, such as better surgical and anesthetic techniques, early diagnosis and use of antibiotics, except in conditions that are easier to detect. aspiration and in the immunocompromised population. Some conditions that can cause or encourage lung abscesses include alcoholism,

Radiological examination is a supporting examination that plays a very important role in the diagnosis of lung abscess, ranging from conventional radiographs as initial screening, to sophisticated examinations such as CT scans and ultrasound. Given that many other lung diseases have a morphology similar to that of a lung abscess on chest radiography, CT scan plays an important role in ruling out the differential diagnosis. On the chest X-ray we can see the shape of the abscess, inflammation of the lung parenchyma and the presence or absence of air-fluid levels, while CT scans can provide other important additional information such as the location and size of the lesion, the outer border, the thickness of the wall, the contents of the cavity, the lesion. Satellites are not visible on chest radiography, assess the presence or absence of obstructive endobronchial lesions and view all lung structures.

2. METHOD

Lung Anatomy

The lungs are formed after the embryo is 3 mm long. The formation of the lung begins in the groove originating in the foregut (Fig. 1). Each lung is divided into several lobes; two lobes in the left lung and three lobes in the right lung. In the right lung there are 10 right bronchopulmonary segments, namely 3 segments in the right upper lobe (apical, anteri-or and medial), 2 segments in the right middle lobe (medial and lateral) and 5 segments in the right lower lobe (superior, medial, anterior). , lateral and posterior) and 8 left bronchopulmonary segments i.e. 4 segments in the left upper lobe (apicoposterior, anterior, superior lingula and inferior lingula) and 4 segments in the left lower lobe (superior, an-teromedial, lateral and posterior) (Fig. 3). Each of these segments will branch again, and after 6-20 divisions these bronchial segments no longer have cartilaginous structures in their walls and are called bronchioles. Bronchioles branch into terminal bronchioles. At the ends of these terminal bronchioles are the acini, the smallest units of the lungs that are the site of respiratory gas exchange. 7,10,11

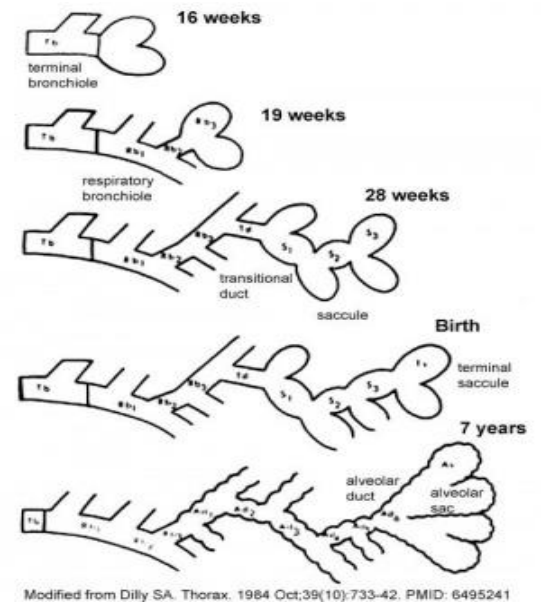


Figure 1. Pulmonary Embryology. Taken from: www.embryology.med.unsw.edu.au

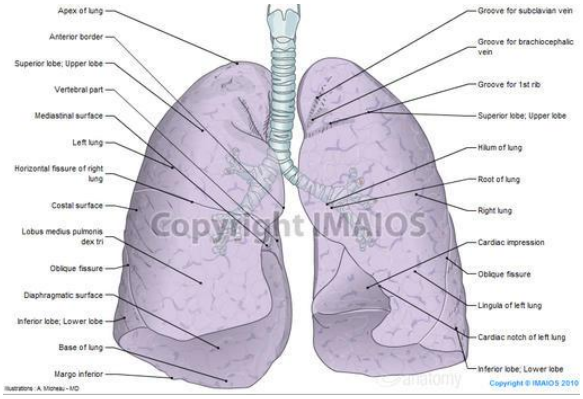


Figure 2. Anatomy of the lungs. Taken from:www.imaios.com/chest-anatomy-illustrations

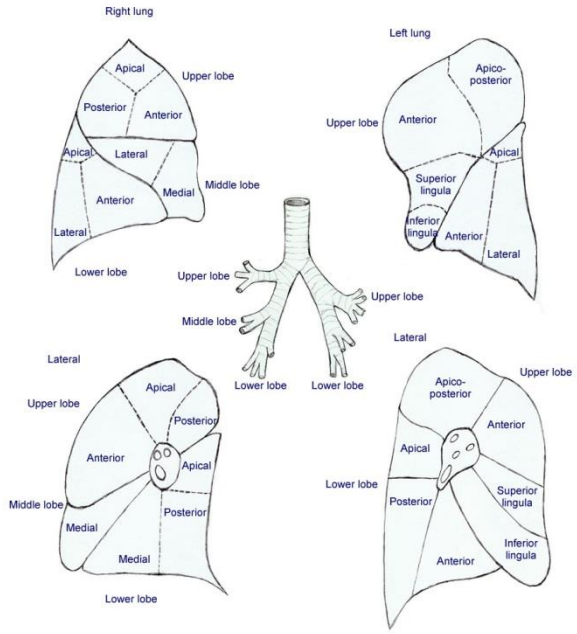


Figure 3. Lung segments. Taken from:www.emedicine.medscape.com

The pulmonary vessels are mainly formed by the pulmonary arteries and veins. Each bronchopulmonary segment has its own pulmonary artery branch. The main pulmonary artery originates from the right ventricle and divides into 2 branches. The right pulmonary artery passes between the superior vena cava and the right main bronchus and then divides into an upper branch (truncus anterior) and a descending interlobar branch. The left pulmonary artery runs along the left main bronchus. In the right lung there are 3 pulmonary veins; descending superior pulmonary vein, middle lobe vein, and inferior pulmonary vein. In the left lung there are 2 veins; The superior pulmonary veins supply the upper lobes and the lingula, and the inferior pulmonary veins supply the lower lobes (Fig. 4). 7,10,11

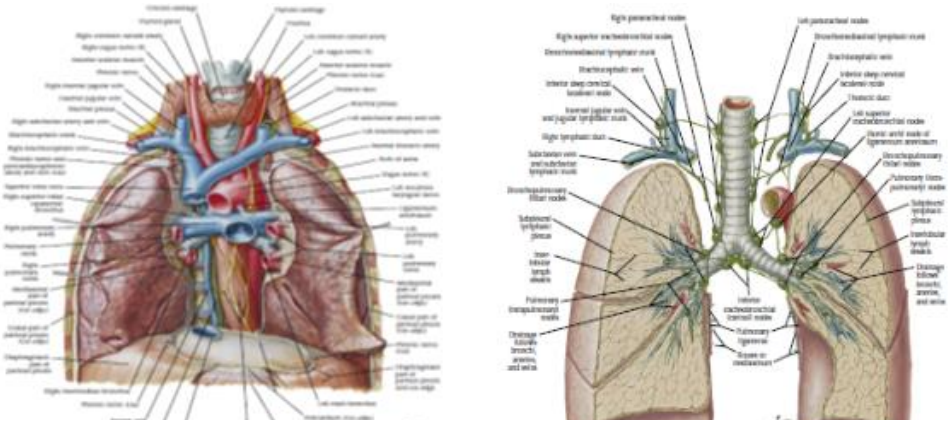


Figure 4. Vascularization and the pulmonary lymphatic system. Taken from:www.netter's-image.com

The pulmonary lymphatic system begins with lymph vessels leading to the intra-parenchymal lymph nodes of the lung, then drains to the peri-bronchial (hilar) lymph nodes, sub-carina, tracheobronchial tree, and paratrachea. The pulmonary lymphatic system communicates with the venous system via the bronchomediastinal lymphatics and thoracic ducts or through the deep inferior cervical lymph nodes (scalenus) (Fig. 4).7,10,11

Epidemiology

The incidence and mortality from lung abscesses has decreased dramatically in recent decades due to the increasing use of antibiotics and the availability of other therapeutic options. Currently there is a change in the pattern of lung abscess disease in developed countries where lung abscess secondary to malignancy and immunosuppression is more common. In France, an increased incidence of lung abscess was found in the pediatric population in 1999 and 2003. The incidence of lung abscess is about 4-5 per 10,000 hospitalized patients per year. Lung abscesses can be found at any age, mostly in the sixth to eighth decades of life, and are more common in men.

Table 1. Causes of lung abscess

Abscess Type	Organism
primary	*S. aureus* *H. influenza* *S. viridans, pneumonia* *S alpha hemolyticus* *Neisseria sp* *M. pneumonia*
Secondary	**aerobics** H. aphropilus *H. parainfluenzae* *S. group B* *K. pneumonia* *E. coli* *P. pyocyanea* *A. aeruginosa* *Candidate*

	Rhizopus sp *A. fumigatus* *Nocardia sp* *E. corrode* *S. marcescens* **anaerobic** P. constellation *Veillonella sp* *Bacteroides sp* *Fusobacterium sp* Bifidobacterum sp

Pathogenesis

Lung abscesses are classified based on the following factors: (1) causative organism (such as anaerobic lung abscess or staphylococcal lung abscess), (2) presence of odor in coughed up sputum (pupillary lung abscess), (3) duration of symptoms before diagnosis (acute, symptoms present for less than two weeks; sub-acute, symptoms appearing for more than two weeks; chronic, symptoms appearing for more than one month); or (4) presence or absence of other associated conditions (such as lung cancer, AIDS, immunosuppression) . The term primary lung abscess is used when the abscess occurs in an aspirated individual or a previously healthy individual. A secondary lung abscess indicates the presence of a neoplasm or foreign body obstructing the airway, a complication of thoracic surgery, or a systemic condition or treatment that results in a weakened immune system, as in patients with AIDS and immunosuppressant therapy. Approximately 80% of lung abscesses are primary lung abscesses.

The incidence of lung abscess in patients previously known to have aspiration is caused by impaired consciousness, such as in alcoholics, seizure disorders, stroke, drug abuse, and patients receiving general anesthesia. Other causes of aspiration include dysphagia due to esophageal and nerve disorders, respiratory muscle disorders due to myotrophic lateral sclerosis, Parkinson's disease, tooth extraction, and use of mechanical devices such as nasogastric tubes (NGT) and endotracheal tubes (ETT). In general, patients with lung abscess have poor oral hygiene accompanied by gingivitis which facilitates the growth of anaerobic bacteria. Several studies have stated that 50% of cases of lung abscess in the population over 50 years are associated with lung carcinoma, either due to infection due to blockage by the tumor or due to infection due to the process of tumor necrosis itself. Other causes of airway obstruction that can lead to lung abscess are foreign bodies and extrinsic compression of enlarged lymph nodes. 1.2

3. RESULTS AND DISCUSSION

Radiological Examination

Conventional Radiography

The radiological appearance of this lung abscess may be normal or with a diffuse or localized alveolar infiltrate within the first 72 hours, and will change within a few days. The cavity formed is thick-walled, irregular, round in shape with a diameter of >2 cm (but can also be >12 cm), the boundaries are not clear and there is usually an air-fluid level in it (Fig. 6). The thickness of the abscess wall can change from thick to thin and from indistinct to well-defined as the infection repair process occurs. The hallmark of this lung abscess is that the dimensions of the lesion on the frontal projection are almost the same as the dimensions on the lateral projection. A lung abscess may extend to the pleural surface so that it forms an acute angle with the pleural surface (Fig. 9). Cavities formed can be multiple

and multilobar (necrotizing pneumonia), usually occurs in immunocompromised patients (Fig. 8). 1,6,12,13,14,15,

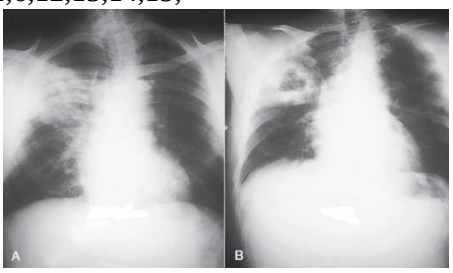


Figure 6. Bacterial lung abscess. (A). Chest X-ray when he was admitted to the hospital, showed a broad infiltrate without a clear cavity. (B), X-ray after six days of treatment, shows a large, thick-walled cavity with a liquid-air level. Taken from: Lorber B. Bacterial Lung Abscess. In: Bennet JE, et al, editor. Infectious Disease Principles and Practices. Ed-8. Philadelphia: Elsevier, 2015. p. 857

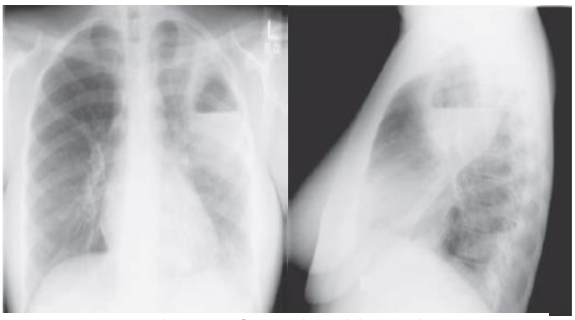


Figure 7. Lung abscess, frontal and lateral projections. Taken from: Misra R, et al. Lung Abscess. In: AZ Chest Radiology. New York. Cambridge University Press. 2007. p.23

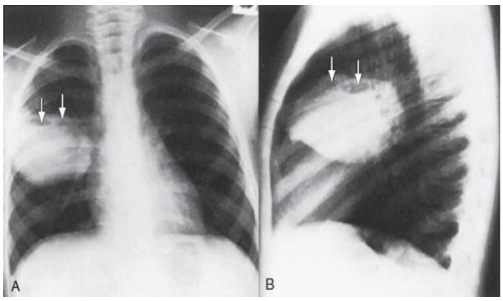


Figure 8. Multiloculated lung abscess. Taken from: Lakser O. Lung Abscess. In: Kliegman RM, editor. Nelson's Textbook of Pediatrics. Ed-18. Philadelphia: Elsevier, 2011. p. 1480

Figure 9. Necrotizing cavitating pneumoniae due to S. aureus in AIDS patients. Taken from: Allen CM, et al. Imaging of HIV/AIDS Lung Manifestations. Journal of Annals of Thoracic Medicine, 2010; 5(4): 206

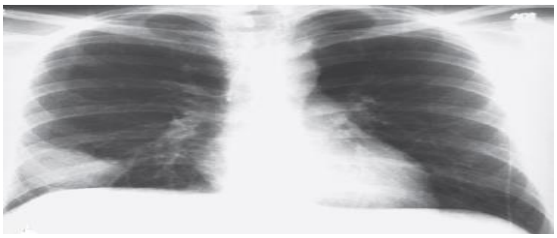


Figure 10. Lung abscess, on conventional radiographs it can be a solid lesion, and if there is a connection with the bronchus it will form an air-fluid level. Taken from: Ferri FF. Lung Abscess. Ferri Clinical Advisor. Ed-1. Philadelphia: Elsevier, 2014. p. 15

Computer Tomography

CT scanning is widely recognized as the most superior radiological modality in assessing the lung parenchyma. The good contrast resolution capability and the presence of non-superiomposed thoracic structures allow high-resolution CT (HRCT) to be the most sensitive imaging modality for assessing pathological processes in the lung parenchyma, including lung abscesses.

Figure 11. CT scan can be used to locate the lesion and to place a drainage needle and aspirate the contents of the lesion. Taken from: Ferri FF. Lung Abscess. Ferri Clinical Advisor. Ed-1. Philadelphia: Elsevier, 2014. p. 15

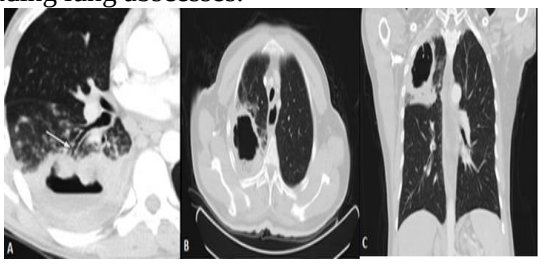


Figure 12. Lung abscess. (A, B, C), axial and coronal CT scans, showing cavities with air-fluid levels. The abscess wall appears hard with an air-fluid level in it. There are bronchial branches leading to the center of the lesion. Taken from: www.mypacs.net

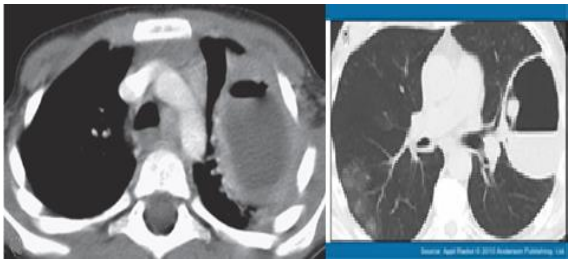


Figure 13. (A). Lung abscess, CT scan shows strong thick-walled abscess with air-fluid level. (B). CT scan of a leukemia patient, showing cavities with air-fluid levels. On examination of bronchoalveolar lavage, the results of bacterial culture in the form of Klebsiella were found. Taken from: www.medscape.com

Figure 14. Lung abscess. CT scan with contrast axial shunt, showing a large cavity in the left lower lobe with a thick wall (black arrow), smooth inner wall and air-fluid level (white arrow). There is also an inflammatory reaction around the lungs (yellow arrow). Taken from: www.learningradiology.com

Ultrasound (Ultrasound)

Ultrasound examination is a less than optimal modality for cases of lung parenchyma, especially lung abscesses because of poor sound wave transmission when passing objects that contain a lot of air such as lungs. However, recently there has been an increasing use of ultrasound for the evaluation of lung parenchymal disease located in the periphery, pleura and chest wall. The study of Yang PC et al in 1992 found that ultrasound is more sensitive than conventional radiography in assessing lung necrosis and abscesses. Ultrasound is very useful because it is real-time and multiplanar. In addition, ultrasound is portable so that it can be used for emergency room and intensive care unit (ICU) patients. In addition, currently ultrasound is even used as a guide in interventional procedures such as biopsy and insertion of intercostal chest drainage.

The appearance of a lung abscess on ultrasonography is quite characteristic, with a round or oval hypoechoic lesion with irregular borders (Fig. 12). The center of the abscess is often anechoic but may also be septate with internal echoes. Blurred internal echoes indicate the presence of large amounts of

protein-rich pus, whereas septa appear as floating echo stripes. In its early stages, a small lung abscess is seen as a pathological collection of fluid in the consolidation of the lung which gives a textured appearance to the liver. Lung abscess with air-fluid level will appear more inhomogeneous.

Figure 14. (A). Grayscale ultrasound shows hypoechoic lesion with microbubble sign (arrows), wall thickness varies with irregular outer and inner wall contours (arrows). (B). Color Doppler ultrasound shows vascularization around the cavity (arrows). Taken from: Chen HJ, et al. Ultrasound of Peripheral Lung Air-Fluid Lesions. Chest. 2009; 135:1429

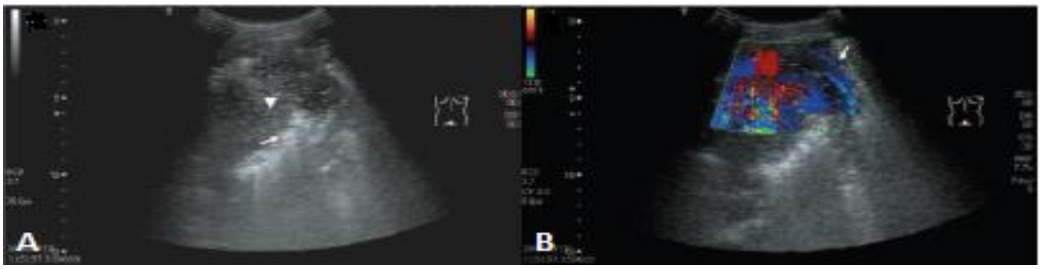


Figure 15. Lung abscess. (A). Grayscale ultrasound, showing a hypercoic lesion with microbubble markings (arrows), surrounded by lung parenchyma. (B). Color Doppler ultrasound, showing vascular signals in consolidation around the cavity. Blood vessels appear congested, branched and coiled. Taken from: Chen HJ, et al. Ultrasound of Peripheral Lung Air-Fluid Lesions. Chest. 2009; 135:430

Magnetic Resonance Image (Mri)

In general, MRI has a very good ability to assess soft tissues, but the use of MRI in the evaluation of lung pathological processes is very limited due to the presence of artifacts and relatively low spatial resolution. Vascular structures are also more difficult to assess especially in non-contrast sequences. However, in conditions where repeated radiological evaluation is required, such as in the case of

pulmonary abscess in children, MRI is the first choice because of its ability as a radiation-free radiological modality.

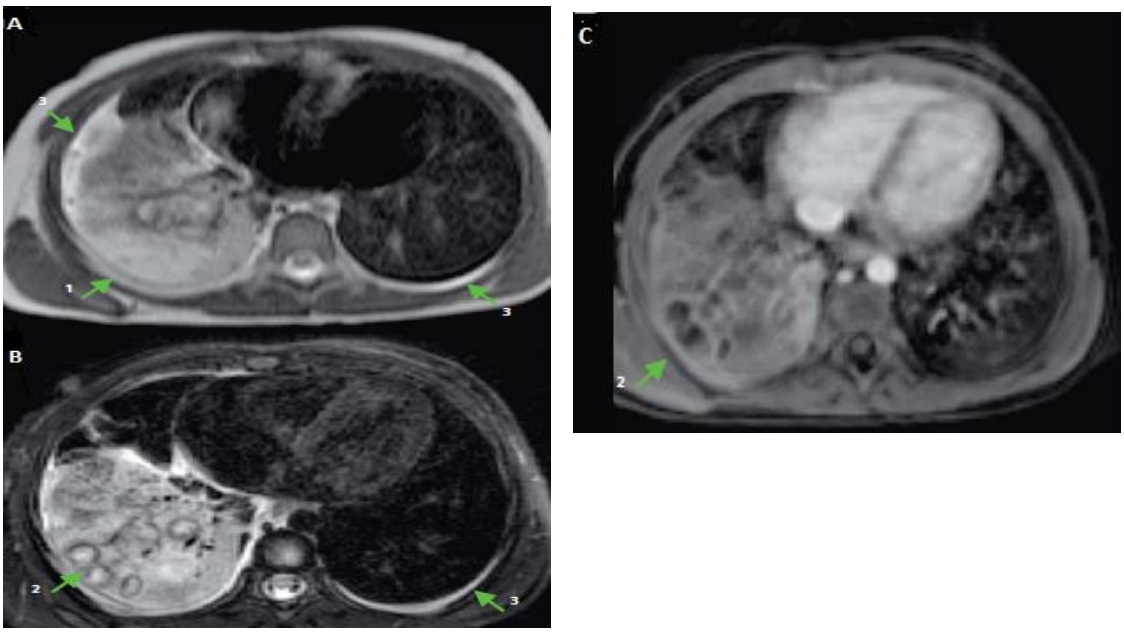


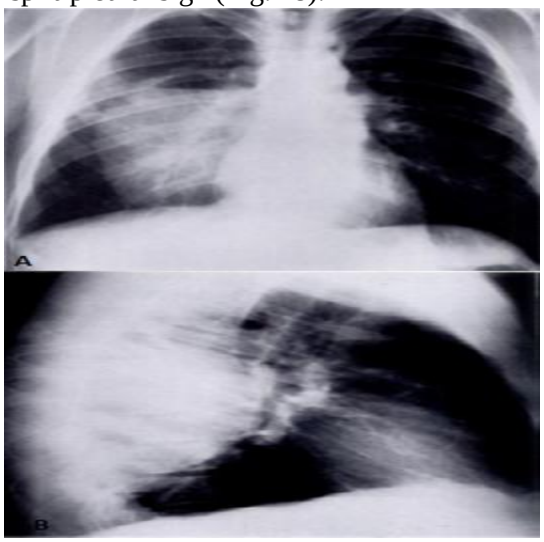
Figure 16. Axial MRI. (A) T2W HASTE, (B) syngo BLADE, (C) T1W VIBE post contrast, showing a lung abscess in the lower lobe of the right lung. Homogeneous area with increased T2W signaling (consolidation) in the right lower lobe (1) and multiple inclusions in T2W hyper and T1W hypointense with peripheral enhancement (2). Bilateral pleural effusions are also seen (3). Taken from: Sumkauskalte M, et al. Case Report: Lung MRI in a Young Child with Pneumonia Abscess due to H1N1 Infection. Clinical Thoracic. 2011; 11:76

Radiological Differential Diagnosis

Radiological features of lung abscess can also be found in many other pulmonary pathological processes. The presence of a cavity can be used to rule out other differential diagnoses but must be combined with clinical and laboratory data to reach a precise and accurate diagnosis.

empyema

Thoracic empyema or pyothorax refers to a purulent infection from a pleural effusion. On conventional radiographic examination, empyema may resemble a peripheral lung abscess. The empyema forms an obtuse angle with the chest wall, and because of its lenticular shape it will appear larger in one projection (eg frontal) than in the orthogonal projection (eg lateral projection) (Fig. 17) On CT scan the empyema will appear as amplification of the pleura, especially the pleura. parietal and the presence of a split-pleural sign (Fig. 18).



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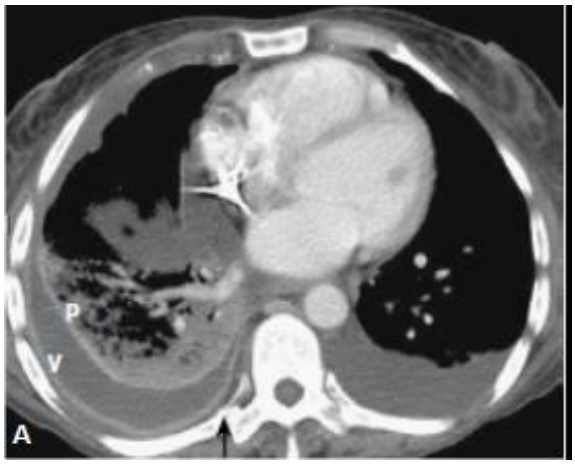

Figure 17. Empyema. (A), PA projection. (B), lateral projection. Peripheral fluid collections appear with smooth outer edges, accompanied by intra-lesional free air. Taken from: Stark DD, et al. Distinguishing Lung Abscess and Empyema. American Journal of Roentology. 1983; 141:166

Figure 18. (A). Split-pleural sign. Visceral (P) and parietal (V) pleural enlargement and separation are seen and extra-pleural fat increase (arrows). Compare this with a pleural effusion in the left lung. (B). Thoracic empyema with septa. Taken from:Stark DD, et al. Distinguishing Lung Abscess and Empyema. American Journal of

Cavity Lung Cancer

Cavities are seen in 2-16% of all lung cancers. Cavities detected on conventional radiographs account for 7-11% of all primary lung cancers, whereas those detected on CT scans account for 22%. On radiological examination, masses can be located peripherally or centrally, have smooth or irregular edges and may cavitate. The cavity formed is usually thick-walled (>5 mm thick), is eccentric in shape and has nodular internal borders (Fig. 19).

Figure 19. Non-small cell lung carcinoma. The cavity appears with an air-fluid level. Taken from: www.emedicine-medscape.com

Lung Metastasis

Cavities in lung metastases are usually thick-walled and irregular, but may also be thin-walled, especially in adenocarcinomas and sarcomas. On CT scan pulmonary metastases will be seen as nodules with smooth and irregular edges, the boundaries can be firm or unclear. These nodules have soft tissue attenuation and have prominent large pulmonary vessels (Fig. 20).

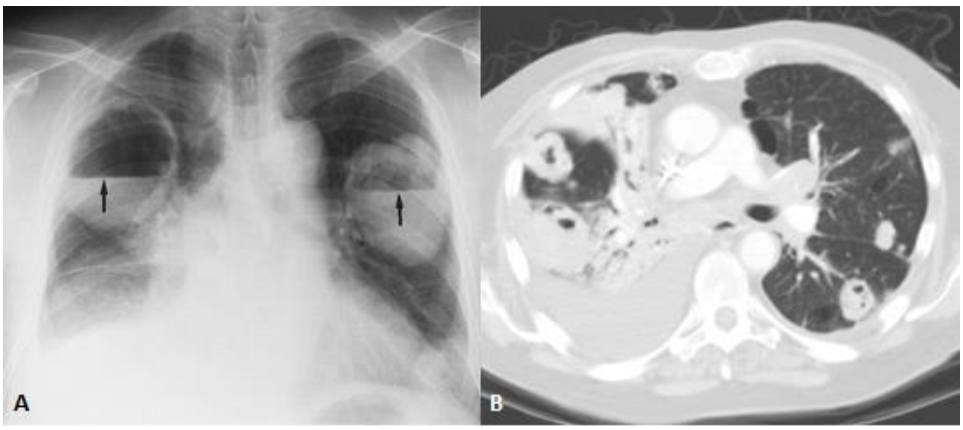

Figure 20. (A). Conventional PA projection radiography. Cavitation lung metastases in squamous cell carcinoma. A cavity with an air-fluid level is shown (arrow). (B). Axial CT scan. Taken from: Seo JB, et al. Atypical pulmonary metastases: a spectrum of radiological findings. radiography. 2001; 21(2)

Granulomatous Disease

respiratory system (95% of cases). On conventional radiographs, they are seen as multiple nodules of varying size, and approximately half of all nodules cavitate. In some cases, focal consolidation of the periphery is also cavitated. On CT scan the cavity is located peripherally, adjacent to the pleura and blood vessels around the cavity can be seen (Fig. 21).

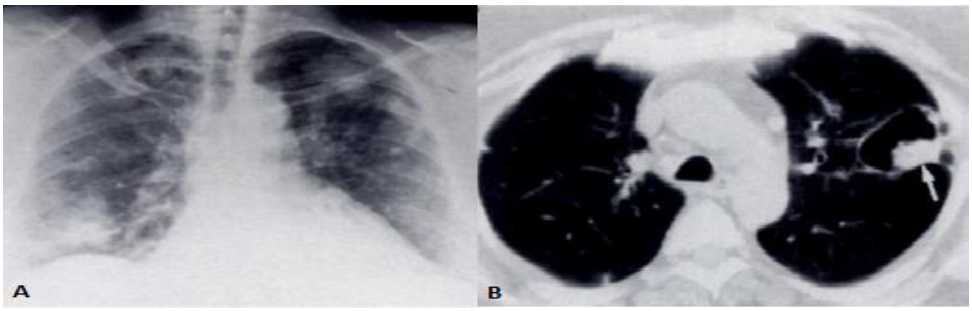

Figure 21. Wegener's granulomatosis. (A). Conventional radiographs show multiple cavities. (B). CT scan shows cavities with air-fluid levels. Taken from: Kuhlman JE, et al. Abnormal Air-Filled Chambers in the Lungs. radiography. 1993; 14:

Infected Pneumotocele

Pneumatoceles are intrapulmonary air-filled cystic lesions that vary in size and appearance. Pneumatoceles appear as air-filled, thick-walled, intraparenchymal cystic lesions. However, if radiological examination is performed at the time of pneumatocele formation, consolidation may be visible and difficult to distinguish from lung abscess (Fig. 22).

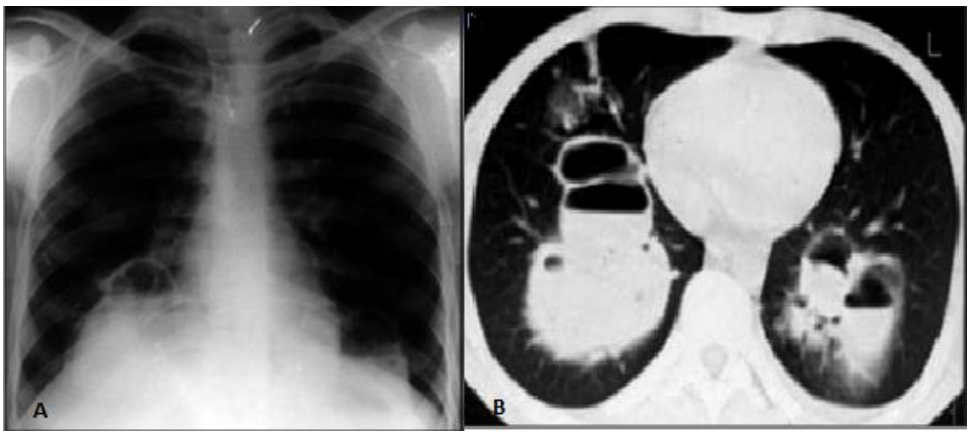

Figure 22. Pneumatocele. (A, B). Conventional radiographs show opacity with air-fluid levels. Taken from: Lizard F, et al. Fire-eating Pneumonia is Characterized by Pneumatocele Formation and Spontaneous Resolution. Radiol Interv Diagnosis. 2010; 16:202

Governance

Antibiotic Therapy

Conservative therapy is the main choice in cases of lung abscess. The choice of initial antibiotic used depends on the possible causative organism. Involvement of gram-negative bacteria should be suspected in immunosuppressed patients, abscesses due to complications of pneumonia, hospital-acquired lung abscesses, or necrotizing pneumonia. Many experts recommend parenteral antibiotics for 2-3 weeks, followed by oral antibiotics for up to 4-6 weeks. Penicillin is the main antibiotic in the treatment of lung abscesses. High-dose oral penicillins have been shown to have high efficacy even in patients with long closed abscess cavities. It has long been known that penicillin is the antibiotic of choice for anaerobic bacteria. but in recent decades it has been found that many oral anaerobic bacteria produce penicillinase. In addition, two clinical trial studies demonstrated that clindamycin was superior to penicillin in the treatment of lung abscesses. The use of Metronidazole as sole therapy showed disappointing results and was inferior to clindamycin. The combination of Metronidazole with Penicillin gives good results at a price that is more affordable and more tolerable.

Chest Physiotherapy And Postural Drainage

Patients with large lung abscesses should be positioned in the lateral decubitus position with the abscess at the bottom. This is to prevent asphyxia and discharge of the abscess contents, causing aspiration or spread of infection to other lung segments. Chest physiotherapy and postural drainage can improve clearance of necrotic and purulent pus from abscesses, but this is still a matter of debate.

Bronchoscopy

Bronchoscopy is still frequently performed, especially in patients with persistent air-fluid levels, patients with sepsis who persists for 3-4 days on antibiotics, or in situations where an endobronchial tumor is suspected. Bronchoscopy procedures are rarely used for drainage of lung abscesses. Rigid bronchoscopy has a greater suction capacity but is a less popular technique today. It is not recommended to use bronchoscopy to drain large abscesses (>6-8 cm in diameter) because of the risk of asphyxia or acute respiratory distress syndrome.

Surgical Therapy

In the pre-antibiotic era, more than 45% of lung abscess patients underwent surgical treatment, and one third of cases ended in death. In recent years, less than 15% (11-21%) of patients underwent

surgery and the overall mortality rate ranged from 10%. Drainage interventions performed on lung abscesses can include:
(1) Video-assisted thoracoscopy, more non-invasive than resection therapy.
(2) Resection of the involved lung by lobectomy or tal-segment resection. The indications for this resection are not well agreed upon, but are generally indicated for patients with large cavities, massive bleeding, empyema, obstructive neoplasms, and infections caused by multiresistant bacteria or fungi. Life expectancy after lung resection ranges from 89-95%.
(3) Ultrasound-guided percutaneous CT scan and drainage. The success rate is about 90% and should be considered as initial therapy in patients who fail conservative therapy.

4. CONCLUSION

Death of patients with primary lung abscess is rare (approximately 2-5%), but fatal outcomes are seen in 65% of cases associated with obstructive airway disease, immune disorders and nosocomial infections. Several factors associated with poor prognosis are advanced age, prolonged symptoms, presence of comorbidities, nosocomial infections and large cavities. 2,6,15,44 Lung abscess with radiological features that can mimic many other pulmonary pathological processes is something that radiologists must understand well. The availability of various radiological modalities is currently expected to further improve the acuity of radiological diagnosis so that patient management can be carried out earlier.

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