Imaging Findings of Free-flowing Effusion

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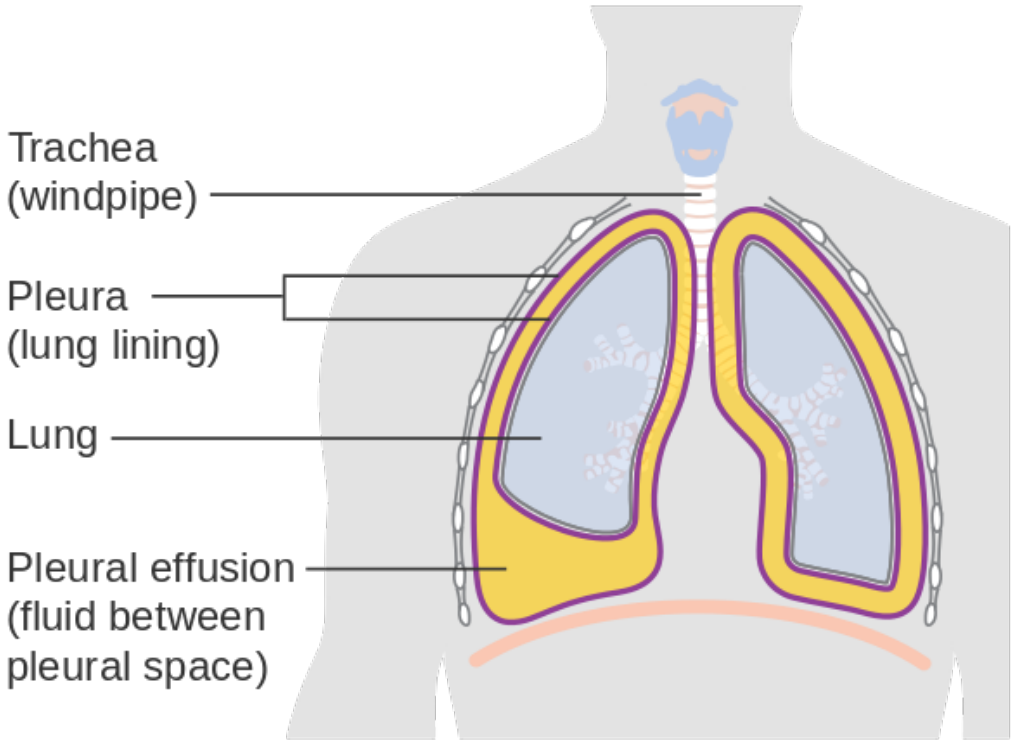
Pleural effusions are a common encounter at the emergency department, outpatient and inpatient wards in hospitals. Up to one-half of the hospitalized patients with bacterial pneumonia are expected to develop or have pleural effusion during their admission. Moreover, up to two-thirds of intensive care unit patients are found to have a pleural effusion for one reason or another.



Overview of Free-Flowing Effusion

Pleural effusion refers to the accumulation of fluid between the layers of tissue (pleura) that cover the lung (visceral pleura) and chest wall (parietal pleura). The plural cavity is a potential space, and any form of fluid accumulating in this space limits lung expansion, thus causing difficulty breathing. The main goal of imaging in a patient suspected of having pleural effusion is to:

- **Determine whether the patient has an effusion or not**
- **Determine the effusion size**
- **Determine the most likely etiology**
- **Determine if the fluid is free-flowing or loculated**. Loculated pleural effusions can happen after pneumonia, but the most typical picture of a pleural effusion is that of free-flowing fluid.

As the name implies, a free-flowing effusion is expected to change in location and shape on conventional radiography or other imaging modalities as the patient changes his or her position. This happens because the fluid of the effusion tends to accumulate within the pleural space without getting trapped by fissures or fibrosis. Therefore, a chronic exudative pleural effusion might eventually evolve into a loculated or multiloculated effusion if it does not resolve spontaneously with proper antibiotic therapy.

Chest Radiography Findings of Free-Flowing Pleural Effusions

When a patient presents with congestive heart failure, thoracic malignant disease, pneumonia, connective tissue disease, or any other potential cause of pleural effusions, the physician will order a chest radiograph to evaluate the lungs' condition as well as the nature and extent of the disease. For instance, a patient with congestive heart failure will have a degree of cardiomegaly or pulmonary edema. A patient with pneumonia might have diffuse lung infiltrates or consolidation.

The chest x-ray will also serve as a baseline for future follow-ups. These diseases tend to evolve over time; in many cases, the physician will be interested in recent changes rather than the mere presence of an abnormality.

Finally, plain radiography can confirm the presence of a pleural effusion. A pleural effusion can provide crucial information about the nature of the pathology, such as malignant cells in an effusion caused by a malignancy, that can exacerbate the patient's symptoms. Therefore, when you are evaluating a pleural effusion on radiography, it is essential to define the size of that effusion to determine whether therapeutic thoracentesis is indicated.

Visualization

Chest radiography is the first imaging modality used to visualize and evaluate pleural effusions because it is readily available, inexpensive, and easy to interpret. Additionally, most pleural effusions that need intervention are generally more than 175 ml in size, which is the typical size of fluid that can be detected on an erect posterior-anterior chest x-ray.

When obtaining a chest x-ray to evaluate an ambulatory patient for pleural effusion, the patient should be in the upright position. In a normal x-ray, the pleural space is not visualized. However, if the fluid has accumulated in this cavity, an opacity in this space is visible. Thus, there are two important early signs: blunting of the costovertebral angle and the meniscus sign.

The costovertebral angle is visible on the posterior-anterior and lateral x-ray views of the chest. The lateral x-ray view can show the posterior costovertebral angle, which gets blunted by as little as 75 ml of free fluid. The angle is in the inferior part of the lateral view of the chest.

The lateral costovertebral angle is visualized with the posterior-anterior view and is usually blunted when the patient has at least 175 or even 250 ml of free fluid, per the literature. Therefore, checking the lateral view while focusing on the posterior costovertebral angle may be a more sensitive approach to detecting free-flowing pleural effusions.

Patients with pleural effusions may also have a meniscus sign, which refers to the formation of a U shape on top of a pleural effusion as the fluid rises along the sides of the pleura. Again, this sign points towards the free-flowing nature of the fluid.

If the patient cannot stand up (i.e., an intensive care unit patient), obtain a decubitus film, if possible, to visualize the layering of the effusion. Layering happens because of the gravitational pull on the fluid. A decubitus view can detect as little as 15 ml of free fluid in the pleural space.

Limitations of Plain Radiography in the Detection of Free-Flowing Pleural Effusion

Unfortunately, up to 10% of free-flowing pleural effusions are missed on a conventional x-ray. A low-quality x-ray might limit the radiologist's ability to detect small effusions. While X-ray imaging can help confirm the presence of pleural diffusion, it cannot indicate the size in most cases. This limitation is very important to consider in a clinical setting; whether a patient is a candidate for thoracentesis mainly depends on the size of the effusion.

Because of these limitations, chest computed tomography (CT) and chest ultrasonography were evaluated for detecting and characterizing pleural effusions.

Computed Tomography Scanning of the Chest for Free-Flowing Pleural Effusion

Currently, computed tomography is the golden-standard for detecting free-flowing pleural effusions. In theory, any pleural effusion, regardless of size, should be detectable on a chest CT. Therefore, a chest CT will reliably confirm pleural effusion in a patient.

Unfortunately, CT has its own limitations; it can detect virtually any pleural effusion, but the differentiating pleural effusions per etiology is very difficult. Additionally, CT uses a significant amount of radiation, which might be considered inappropriate for children or pregnant women.

CT may be unavailable in remote health centers, so the patient would need transport to another facility. It is also more expensive than radiography. Because of these limitations, radiologists investigated the usability of ultrasonography for detecting and evaluating free-flowing pleural effusions.

Pleural Ultrasonography

Pleural ultrasonography has many advantages over the previous two imaging techniques for evaluating free-flowing pleural effusions. Pleural ultrasonography can detect as little as 5 ml of pleural fluid, and its sensitivity goes up to 100% if the size of the effusion is more than 100 ml.

Pleural ultrasonography and volumetric computed tomography can provide accurate information about effusion size, which will affect treatment decisions. In one study, a cohort of acute respiratory distress patients was evaluated for possible pleural effusions.

The detection rate of a pleural effusion by physical examination was 61%, whereas an anterior-posterior chest radiograph only detected 47% of the pleural effusions. An

anterior-posterior chest view was used here because the patients were not ambulatory. On the other hand, the pleural effusion detection rate using pleural ultrasonography was as high as 93%. In this study, computed tomography was used as the gold standard to define true positives.

Therefore, pleural ultrasonography seems like a reasonable alternative to computed tomography for the adequate characterization and detection of small pleural effusions in a clinical setting. Moreover, pleural fluid ultrasonography characterizes the fluid as either anechoic, complex septated, complex non-septated, or homogenously echogenic material. Additional details given by ultrasonography include:

- Possible routes of thoracentesis, pleural biopsy, or chest tube insertion sites
- Distinguishing of pleural fluid from thickening
- Detection of pleurodesis
- Evaluation for hemothorax in a trauma patient

The main limitation of ultrasonography is that it is operator dependent.

References

Soni NJ, Franco R, Velez MI, et al. Ultrasound in the Diagnosis & Management of Pleural Effusions. Journal of hospital medicine. 2015;10(12):811-816. doi:10.1002/jhm.2434.

Notes