Imaging Findings of Free-flowing Effusion

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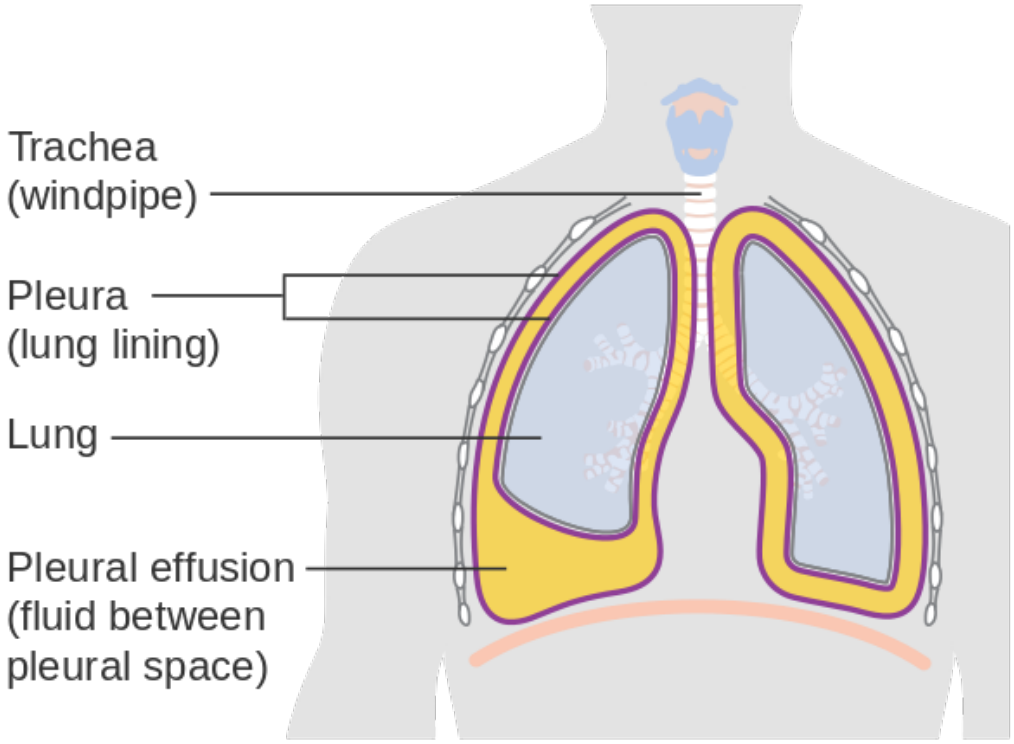
Pleural effusions are a common encounter at the emergency department, outpatient and inpatient wards in hospitals. Up to one-half of the hospitalized patients with bacterial pneumonia are expected to develop or have pleural effusion during their admission. Moreover, up to two-thirds of intensive care 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 in breathing. The main goal of imaging in a patient suspected to have a pleural effusion is to:

- **Determine whether the patient has an effusion or not.**
- **Determine the size of that effusion.**
- **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 might obtain a chest radiograph for three main reasons.

The first objective of obtaining a chest radiograph in a patient with one of the listed conditions is to evaluate the lungs' condition as well as the nature and extent of the disease. For instance, in a patient with congestive heart failure, you might look for the degree of cardiomegaly or the presence of pulmonary edema. A patient with pneumonia might have diffuse lung infiltrates or consolidation.

The second goal of the chest x-ray in those patients is to get a baseline for future follow-ups. These diseases are known to evolve over time, and in many cases, you are interested in recent changes on the x-ray rather than the mere presence of an abnormality.

The last goal of plain radiography is to confirm the presence of a pleural effusion. A pleural effusion can provide crucial information about the nature of the pathology, i.e., malignant cells in an effusion caused by a malignancy, or can exacerbate the symptoms of the patient. Therefore, when you are evaluating a pleural effusion on a radiography, it is essential to define the size of that effusion to determine whether therapeutic thoracentesis is needed.

Visualization

A chest radiography is the first imaging modality used to visualize and evaluate pleural effusions because of its availability, cheap costs, and ease of interpretation. Additionally, most pleural effusions that need an intervention are generally more than 175 ml in size, which is the typical size of fluid required to be detected on an erect posterior-anterior chest x-ray.

When a chest x-ray is obtained for evaluating an ambulatory patient with a suspected pleural effusion, the patient should be in the upright position. In a normal x-ray the pleural space is not visualized, but upon accumulation of fluid in this cavity an opacity in this space is seen. Thus, always look for two important signs: blunting of the costovertebral angle and the meniscus sign, which are the earliest signs visible on the X-ray.

The costovertebral angle can be visualized via the posterior-anterior and lateral x-ray views of the chest. On the lateral x-ray view of the chest you should check 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 is perhaps a better and more sensitive approach to detect free-flowing pleural effusions.

The second sign to look for in a patient with a pleural effusion is the meniscus sign. The meniscus sign is defined as 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), one should aim to obtain a decubitus film, if possible. The main sign to look for on a decubitus view chest x-ray in a free-flowing pleural effusion is layering of the effusion. Layering happens because of the gravity 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. Additionally, a low-quality x-ray might limit the radiologist’s ability to detect small effusions. X-ray imaging is unable to really determine the size of the pleural effusion; it is more of a yes or no exam in most cases.

In other words, it can tell you whether a pleural effusion is present or not, but it cannot give you accurate information about the size of such an effusion. This limitation is very important to consider in a clinical setting, as one of the main dependents to go for thoracentesis is the size of the effusion.

Because of these limitations, chest computed tomography (CT) and chest ultrasonography were evaluated for use in the detection and characterization of pleural effusions.

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

Nowadays, computed tomography is considered 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, whenever in doubt, the physician should obtain a chest CT to reliably exclude the presence of a pleural effusion in a patient.

Unfortunately, computed tomography has its own limitations. While CT can detect virtually any pleural effusion, the differentiation of pleural effusions per etiology is very difficult with this imaging technique. Additionally, CT uses a significant amount of radiation which might be considered inappropriate for children or pregnant women.

Finally, the availability and costs of CT in remote health centers might mean that the patient needs to be transported to another facility. Because of these limitations, radiologists have recently focused on the usability of ultrasonography in detecting and evaluating free-flowing pleural effusions.

Pleural Ultrasonography

Pleural ultrasonography has many advantages over the previous two imaging techniques in the evaluation of free-flowing pleural effusions. Pleural ultrasonography can detect as little as 5 ml of pleural fluid and the 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 the size of the effusion, which might be needed in determining the management plan of the patient. In one study, a cohort of acute respiratory distress patients was evaluated for the possibility of 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 detection rate of pleural effusion by pleural ultrasonography was as high as 93 %. In this study, computed tomography was used as the golden-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