Imaging of Acute Lung Injury

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KEYWORDS

• Acute lung injury (ALI) • Acute respiratory distress syndrome (ARDS)
• Diffuse alveolar damage (DAD) • Acute interstitial pneumonia (AIP)
• Acute fibrinous organizing pneumonia (AFOP) • Acute eosinophilic pneumonia (AEP)

KEY POINTS

- Acute lung injury (ALI) is the clinical syndrome associated with patients who have diffuse alveolar damage on histopathology.
- A variety of diseases may mimic ALI, including hydrostatic edema, infection, aspiration, organizing pneumonia, interstitial lung disease, and acute eosinophilic pneumonia.
- Treatment of ALI is mainly supportive, and no pharmacologic treatment (eg, corticosteroids) has been shown to be convincingly beneficial.
- The key role of imaging is to identify diseases that mimic ALI so that appropriate specific treatment may be instituted.

INTRODUCTION

Acute lung injury (ALI) is a common cause of acute respiratory symptoms in the hospitalized patient, accounting for more than 10% of admissions to the intensive care unit[1] and affecting nearly 200,000 people in the United States yearly.[2] ALI is unique from other causes of dyspnea in its pathophysiologic mechanism of disease. Injury to the alveolar epithelium and capillary endothelium increases alveolar barrier permeability, resulting in airspace edema and inflammation. Because of this unique pattern of injury, the natural history, treatment, and prognosis of ALI differs significantly from other acute lung diseases. The diagnosis of ALI is typically based on clinical and radiographic criteria; however, because these criteria can be nonspecific, diagnostic uncertainty is common. A multidisciplinary approach that synthesizes clinical, imaging, and pathologic data, when available, can ensure an accurate diagnosis. Imaging represents a cornerstone modality in the detection, characterization, and follow-up of patients with suspected ALI, but radiologists must also have a comprehensive knowledge of the clinical and pathologic findings seen in patients with ALI. The goal of this article is to provide a review of ALI with an emphasis on this multidisciplinary approach.

CLINICAL

Definitions

ALI, acute respiratory distress syndrome (ARDS), and diffuse alveolar damage (DAD) all refer to a similar pathophysiologic process; however, they are not synonymous. The first challenge in understanding this topic is to be aware of the subtle, yet important, differences between these 3 terms (**Table 1**). DAD is a histopathologic pattern of injury

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Table 1
Definitions of diffuse alveolar damage, acute lung injury, and acute respiratory distress syndrome

Term	Definition
DAD	A histopathologic pattern of injury characterized by alveolar epithelial injury, proteinaceous edema, hyaline membranes, edema, and eventually fibroplasia
ALI	The clinical syndrome associated with any patient that has DAD pathologically
ARDS	A clinical syndrome defined by 4 criteria: 1. Acute onset (occurring within 1 wk of an insult or after the onset of symptoms) 2. Bilateral opacities on chest radiography (opacities not explained by effusions, collapse, or nodules) 3. Exclusion of cardiac failure or fluid overload as a cause of symptoms (echocardiography often obtained, particularly when there are no risk factors for hydrostatic edema) 4. Reduced oxygenation (3 levels of severity) a. Mild: 200 mm Hg < Pao_2/Fio_2 ≤300 mm Hg b. Moderate: 100 mm Hg < Pao_2/Fio_2 ≤200 mm Hg c. Severe: Pao_2/Fio_2 ≤100 mm Hg

characterized by alveolar epithelial injury, proteinaceous edema, hyaline membranes, edema, and eventually, fibroplasia. The pathologic manifestations of DAD are discussed in greater detail later.

ALI and ARDS, on the other hand, are both clinical syndromes. ARDS was most recently defined in a 2012 consensus statement.[3] It is characterized by the acute onset of hypoxemia and diffuse parenchymal opacities on chest radiograph not explained by cardiogenic edema or fluid overload. ARDS is further categorized into mild, moderate, and severe forms based on the severity of hypoxemia as defined by the ratio of the partial pressure of oxygen in arterial blood to the fraction of inspired oxygen (Pao_2/Fio_2 ratio). ALI, on the other hand, refers to the clinical syndrome associated with any patient who has DAD pathologically, but its use is not limited by the strict clinical criteria that define ARDS. To add further confusion, an older consensus paper[4] defined ALI using similar criteria to ARDS, except with less severe hypoxemia. This definition of ALI was subsequently removed in the 2012 classification because practitioners had been using the term ALI to describe patients who clinically appeared to have ARDS, but did not meet the oxygenation criteria. Presently, the most accurate use of the term ALI is to describe any clinical symptoms or findings that are associated with histopathologic DAD, which include both cases that meet criteria for ARDS and those that do not meet criteria for ARDS.

In many cases, a definitive pathologic diagnosis is not available in patients with ALI or ARDS; thus, the diagnosis is often presumed and based on the exclusion of other causes of acute lung symptoms. As discussed earlier, DAD and ARDS are not synonymous. Not all patients who meet clinical and radiographic criteria for ARDS will have DAD on pathology. DAD mimics that may meet clinical criteria for ARDS are shown in **Box 1**. In a study of ARDS patients undergoing autopsy,[5] only 45% of patients who met criteria for ARDS had DAD on pathology. In the group with mild ARDS, only 14% had DAD on pathology. The most common alternative (non-DAD) diagnoses in this study included pneumonia (49%), no significant lung abnormality (14%), emphysema (7%), pulmonary hemorrhage (6%), and malignancy (5.5%). In another study of open lung biopsy in patients with nonresolving ARDS (persistent hypoxemic respiratory failure >1 week after admission),[6] 58% had DAD on pathology. The most common alternative (non-DAD) diagnoses in this study were interstitial fibrosis (37%), organizing pneumonia (OP; 26%), and alveolar hemorrhage (14%). It is also important to note that not all patients with DAD on histopathology meet clinical

Box 1
Clinical and radiographic mimics of acute lung injury

Hydrostatic pulmonary edema

Rare causes of pulmonary edema (high altitude, high permeability such as interleukin-2 infusion, neurogenic, postobstructive)

Pneumonia without ALI

Aspiration

Diffuse alveolar hemorrhage

Acute hypersensitivity pneumonitis

Organizing pneumonia

Acute eosinophilic pneumonia

Acute fibrinous organizing pneumonia