

# Sponge Lung: Pulmonary edema superimposed on emphysema

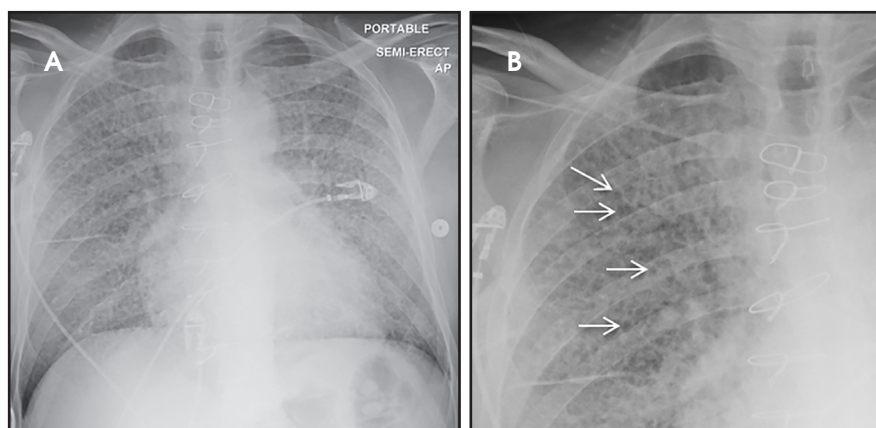
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## CASE SUMMARY

A 54-year-old male with known history of emphysema, coronary artery disease, and congestive heart failure presented with chest pain and shortness of breath of three days' duration. Physical exam is positive for increased work of breathing, diffuse crackles most prominent at the bases, and overall decreased breath sounds. The patient was afebrile with a normal white blood cell count. He was admitted and treatment begun for COPD exacerbation. Shortly after admission, the patient had rapid desaturation requiring treatment with a non-rebreather mask. Imaging was obtained for further evaluation. The patient's B-type Natriuretic Peptide (BNP) was 697 (BNP levels above 600 pg/mL indicate moderate heart failure).

## IMAGING FINDINGS

The patient's imaging findings were consistent with "Sponge Lung", a novel term and appearance not previously described in the radiologic literature. "Sponge Lung" describes the



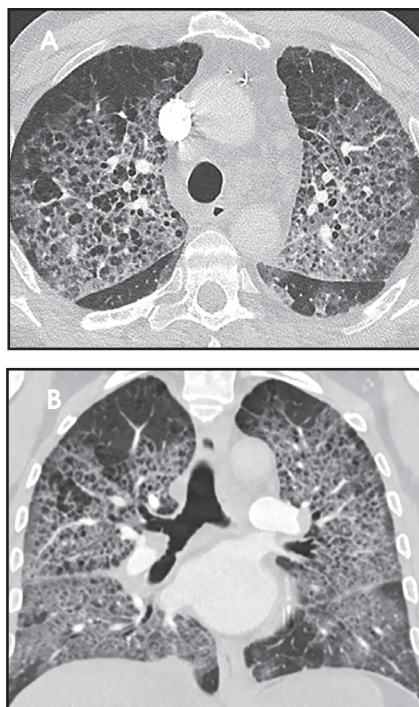
**FIGURE 1.** A 54-year-old man with history of emphysema presenting with shortness of breath. (A) Frontal chest radiograph demonstrates diffuse bilateral reticular opacities with scattered rounded lucencies, representing pulmonary edema superimposed on emphysema. (B) Coned image of the right upper lobe demonstrates the Sponge Lung appearance of these opacities with characteristic rounded lucencies (arrows) and reticular opacities reflecting the underlying architectural distortion of the parenchyma.

appearance of scattered centrilobular lucencies surrounded by reticular and alveolar opacities, creating the appearance of a sponge on radiographs and CT. Radiographically, this appears as bilateral coarse reticular and heterogeneous alveolar opacities with scattered rounded lucencies in a "mesh-like" pattern, resembling a sponge (Figure 1).

On CT, this appears as diffuse, bilateral, smooth, interlobular septal thickening, and ground-glass opacities on a background of innumerable scattered centrilobular lucencies (Figure 2).

## DIAGNOSIS

Pulmonary edema superimposed on background centrilobular emphysema

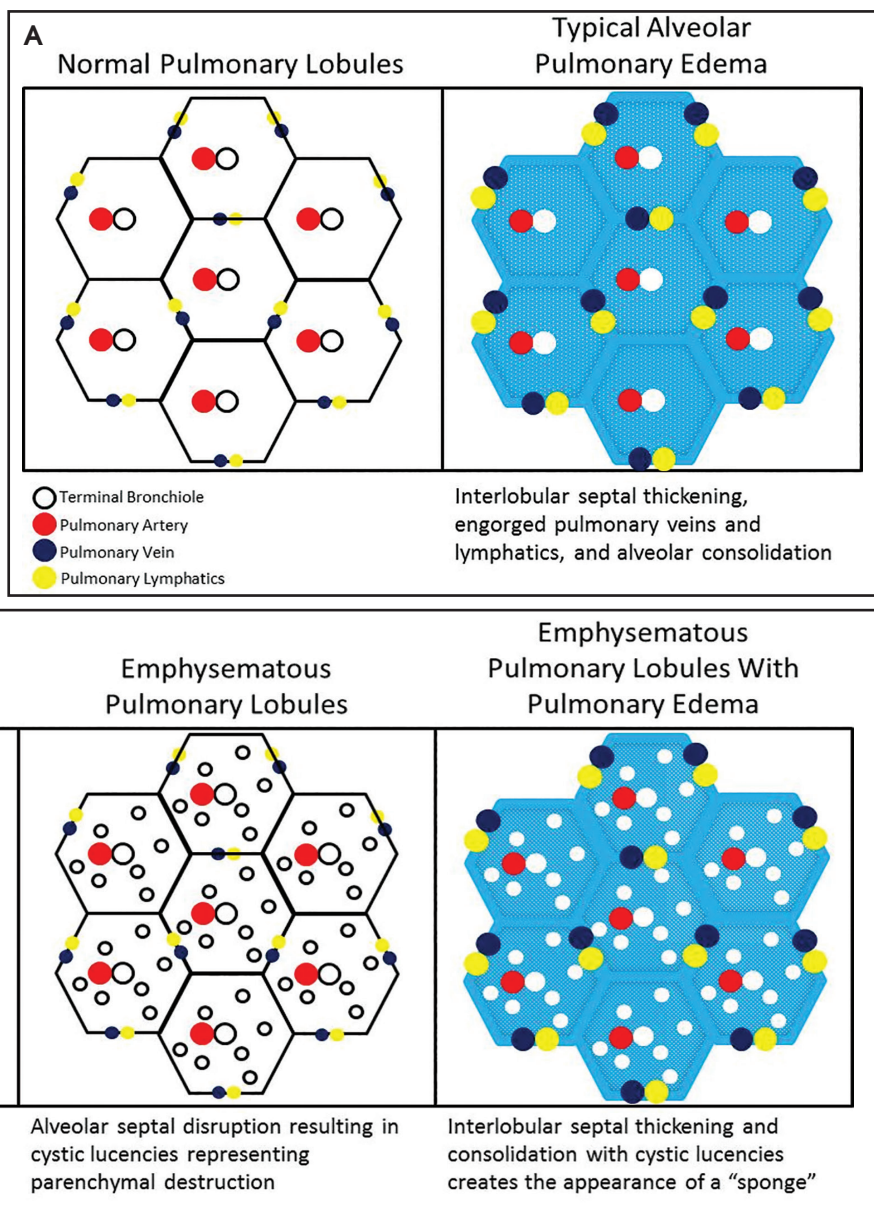


**FIGURE 2.** A 54-year-old man with history of emphysema presenting with shortness of breath. Axial CT image (A) and coronal reformation (B) demonstrating *Sponge Lung* appearance due to pulmonary edema superimposed on emphysema.

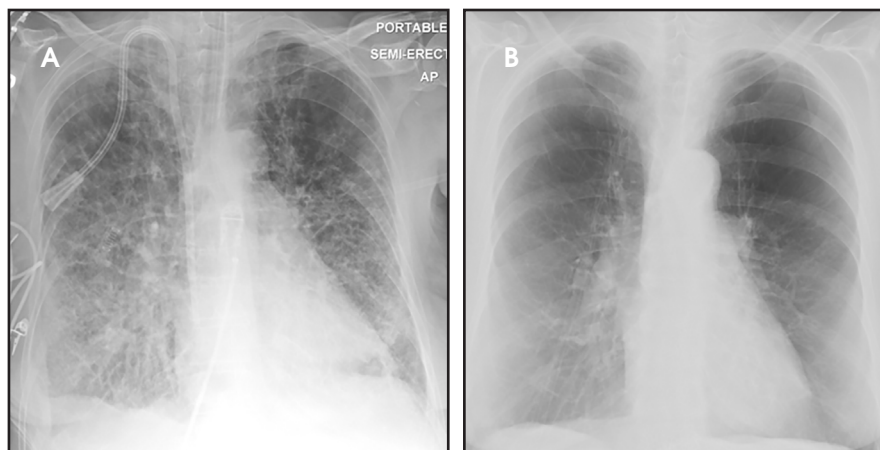
### DISCUSSION

Classic radiologic patterns of pulmonary edema are rarely observed in the setting of background lung parenchymal disease with architectural distortion, particularly in the case of emphysema. Emphysema is defined by chronic abnormal inflammatory cell response resulting in destruction of

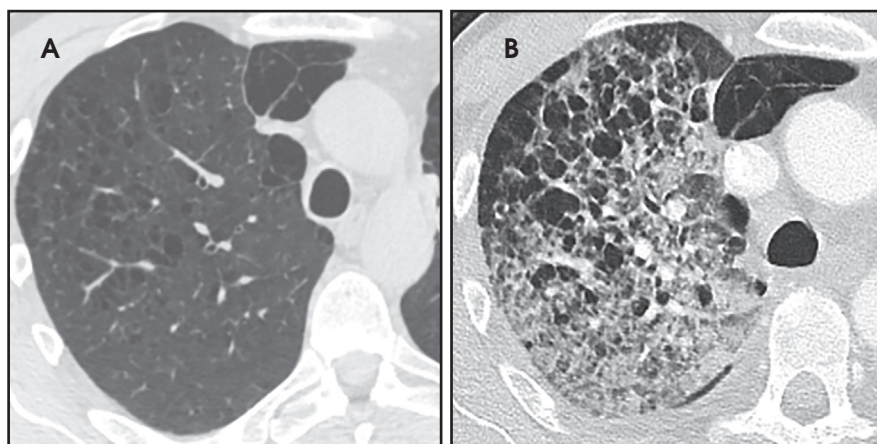
small airway and alveolar walls, with coalescent destructive lesions producing larger cavities resulting in bullous disease.<sup>1</sup> This alveolar destruction results in lung parenchymal distortion, making superimposed processes, particularly pulmonary edema, difficult to accurately identify. Though not comprehensively described in existing



**FIGURE 3.** (A) Schematic diagram of the secondary pulmonary lobule in the absence of underlying chronic lung disease, with and without typical pattern of pulmonary edema. (B) Schematic diagram of the secondary pulmonary lobule with chronic emphysema, resulting in alveolar destruction, with and without pulmonary edema. Note the difference in appearance from typical pulmonary edema.



**FIGURE 4.** (A) A 61-year-old woman with history of COPD presenting with sepsis of intra-abdominal origin who received multiple transfusions and aggressive fluid resuscitation, resulting in pulmonary edema and Sponge Lung pattern. (B) The same patient 1 month later shows resolution of pulmonary edema with background findings of emphysema.

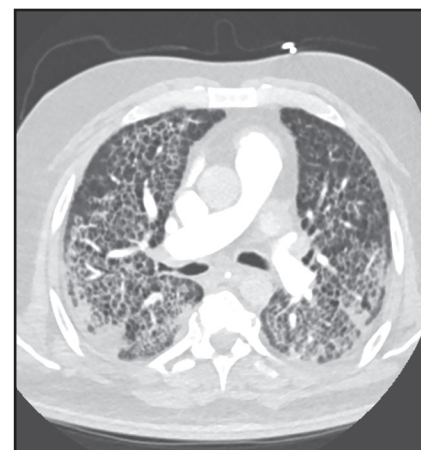


**FIGURE 5.** A 53-year-old man with history of tobacco use. (A) Axial CT image demonstrates centrilobular and paraseptal emphysema in the right upper lobe. (B) Axial CT image of the same patient 8 months later shows post-operative appearance after aggressive fluid resuscitation and consequent pulmonary edema producing a Sponge Lung appearance.

literature, the notion that radiologic evidence of heart failure is influenced by the presence of emphysema has been recognized. In particular, asymmetric, regional, and reticular patterns of pulmonary edema are commonplace in those with emphysema.<sup>2,3</sup>

Regional patterns are observed because edema can only physiologically occur in the presence of an intact parenchymal bed. In the case of emphysema, there is often apical predominant destruction of lung tissue, confining edema in a regional distribution to the

lower lung zones.<sup>4</sup> Reticular patterns of edema, radiographically indicated by the presence of Kerley A and Kerley B lines, have also been described as occurring with increasing frequency in the presence of emphysema.<sup>5</sup> This is attributed to impairment of lymphatic flow in the chronically diseased lung with decreased compliance and elasticity, resulting in stasis and engorgement of the lymphatic network even in the absence of significantly elevated pulmonary venous pressures. Therefore, even a slight increase in pulmonary venous pressures, much



**FIGURE 6.** A 51-year-old man with history of emphysema, hepatitis B, and hepatitis C who presents with shortness of breath and fever. Axial CT image shows a Sponge Lung appearance with consolidative and ground-glass opacities surrounding scattered lucencies. Further workup, given the patient's risk factors, revealed the patient to be HIV positive with CD4 count of 27. Bronchoscopy and BAL were performed and were positive for *Pneumocystis jirovecii*.

less than needed in a non-diseased lung, can tip the patient into interstitial edema with a reticular pattern. Nodular patterns of edema have also been described with underlying emphysema, attributed to the impairment of collateral ventilation through the pores of Kohn and channels of Lambert.<sup>6</sup>

In our experience, however, a new radiologic pattern of pulmonary edema superimposed on emphysema is often seen, one that we term *Sponge Lung* due to its characteristic appearance, not previously described in the radiologic literature. As discussed, emphysema leads to distortion of the lung parenchyma due to alveolar destruction, specifically creating rounded lucencies within the secondary pulmonary lobule (Figures 3-5). When a superimposed diffuse interstitial and alveolar process then occurs, it accentuates these lucencies within the secondary pulmonary lobule amongst surrounding opacity creating the appearance of a sponge on radiographs and CT.

The development of regional air-space disease with scattered areas of radiolucency in a patient with centrilobular emphysema has previously been described in patients with pneumonia and has been termed a “Swiss Cheese” appearance, which describes non-uniformly perforated emphysematous lung tissue amidst dense consolidation.<sup>7-9</sup> However, both the pathophysiology and imaging of Sponge Lung shows a different appearance. Rather than the dense consolidation manifest in the “Swiss Cheese” appearance, Sponge Lung is characterized predominantly by interlobular septal thickening and ground-glass opacity.

Recognizing the appearance of pulmonary edema superimposed on emphysema has many clinical implications. First, the coexistence of heart disease and emphysema is not uncommon. In addition, it is widely known that COPD delays the diagnosis of CHF. When patients without known respiratory disease complain of dyspnea or fatigue during exercise, they routinely undergo noninvasive cardiac imaging that establishes the diagnosis of heart failure when it demonstrates left ventricular (LV) dysfunction. When patients with stable COPD complain of dyspnea or fatigue during exercise, however, these symptoms are often attributed to COPD, and noninvasive cardiac imaging is routinely performed, leaving potential LV dysfunction undetected. Therefore, there is potential for radiologists to make significant contributions in a patient’s overall disposition and treatment by recognizing the appearance of pulmonary edema and findings of congestive failure superimposed on a background of

emphysematous changes with important therapeutic implications.<sup>10</sup>

Recognition of Sponge Lung is important as CT findings are often mistaken for interstitial lung disease, potentially resulting in unnecessary biopsies and bronchoscopy, which in and of themselves carry significant procedural risk in patients who frequently have comorbid conditions. The reticular pattern observed radiographically is often misinterpreted as diffuse fibrosis, peribronchial fibrosis, honeycombing, suspected bronchiectasis, pleural-pulmonary scarring, or diffuse cystic lung disease.<sup>3</sup> Sponge Lung is not specific for pulmonary edema and may represent any diffuse alveolar process superimposed on emphysema, including atypical infections, pulmonary hemorrhage, or non-cardiogenic causes of pulmonary edema. However, given that the most common etiology of a diffuse bilateral process in this population is pulmonary edema, the appearance of Sponge Lung should be interpreted as pulmonary edema superimposed on emphysema in the absence of clinical factors suggesting other possible etiologies, e.g. an immunocompromised patient (Figure 6).

## CONCLUSION

Pulmonary edema superimposed on emphysema has been termed Sponge Lung due to its characteristic likeness to the appearance of a sponge. On radiographs, this appears as diffuse reticular and alveolar opacities with scattered rounded lucencies. On CT, this appears as smooth interlobular septal thickening and alveolar consolidation/ground-glass on a background of centrilobular lucencies.

Sponge Lung fittingly also describes the underlying physiology of pulmonary edema, i.e. lung parenchyma acting as a reservoir for transudative fluid, much like a sponge.

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