A 27-year-old woman presented to the ED with left-sided pleuritic chest pain, general malaise, and flu-like symptoms of 3 days duration. She had no previous medical history. She was a nonsmoker and had no history of substance abuse. Her examination was recorded to be normal, including temperature, BP, pulse, and pulse oximetry. She had peripheral blood leukocytosis (19 × 10⁹/L) and raised C-reactive protein of 320 mg/L. Chest radiography showed left lower lobe consolidation and blunting of the costophrenic angle (Fig 1). She was diagnosed with community-acquired pneumonia with CURB-65 score of 0 and was discharged home with oral antibiotics. She re-presented 2 days later with worsening chest pain, malaise, and subjective fevers. Vital signs were normal, but auscultation of the chest revealed crackles in the left base. Peripheral leukocytosis (14 × 10⁹/L) and raised C-reactive protein (420 mg/L) persisted. Chest radiography showed an increase in the size of the left lower lobe consolidation and pleural effusion (Fig 2). A bedside ultrasound scan was performed (Video 1).

**Question:** What are the ultrasound findings that were shown?
**Answer:** The left lung lower lobe showed atelectatic/hepatized lung distal to the shred sign (irregular deep margin of consolidation), separating it from aerated lung. Note the presence of fluid bronchograms (rounded/cylindrical hypoechoic areas within the lobe representing fluid-filled dilated bronchioles, distinguishable from the accompanying blood vessels by absent color flow). There were no dynamic or static air bronchograms. The lateral costophrenic angle of the left lower lobe showed a double concave edge and was tethered to the diaphragm. There was a small adjacent parapneumonic effusion (Video 2).

She was hospitalized and started on IV antibiotic treatment for pneumonia and parapneumonic effusion. After 48 hours, there was clinical improvement, and C-reactive protein reduced from 420 mg/L to 220 mg/L. However, a repeat ultrasound scan showed unchanged findings of persistent fluid bronchograms and absent air bronchogram that raised concerns regarding an endobronchial obstruction causing postobstructive pneumonia. CT scans of the thorax showed an enhancing endobronchial lesion in the left lower lobe bronchus, consolidation distal to it (Fig 3) and increased size of pleural effusion. Fluid bronchograms were not evident on the CT scan. The effusion was drained, revealing an inflammatory exudate with pH 7.4, glucose 3.6 mM, lactate dehydrogenase 1,220 international units/L, and protein 36 g/L. Microscopy revealed a predominance of neutrophils, but no growth on culture.

Bronchoscopy revealed a rounded exophytic lesion of increased vascularity completely occluding the left lower lobe bronchus distal to the take-off of the apical segment (Fig 4). Tumor biopsy followed by airway recanalization were performed. Histopathologic evaluation showed low-grade neuroendocrine tumor cells consistent with a typical carcinoid with a proliferation index of <1%. After recanalization, the nonaerated portion of the left lower lobe decreased on ultrasound evaluation and was replaced partially by aerated lung with increased B-lines. The fluid bronchograms were still present, but dynamic air bronchograms within this segment were suggestive of at least partial patency of the left lower lobe (Video 3). A $^{68}$Ga-DOTA octreotate PET-CT scan showed the obstructing lesion with no evidence of distant spread (Fig 5). The patient completed antibiotic treatment with control of pneumonia and parapneumonic effusion. She subsequently underwent video-assisted thoracoscopic and left lower lobectomy for complete resection of the carcinoid tumor (Narration Video).

**Discussion**

Normal lung is identified on thoracic ultrasound scanning by the presence of lung sliding and A-lines, the result of a long path reverberation artefact. Sonographic findings in pneumonia are well-described. Early stages of pneumonia can be identified by increased B-lines, arising from a short path reverberation artefact in which the ultrasound beam gets caught between two highly reflective surfaces (in this case, reverberation within fluid-filled alveoli or edematous interlobular septae). The presence of subpleural consolidations causes the visceral pleura to appear irregular, differentiating pneumonic B-lines from other causes of interstitial oedema, such as...
cardiac failure. Dense consolidation that develops as pneumonia progresses is identifiable sonographically as areas of hepatization of lung. This hepatized area usually contains normal vasculature and air bronchograms and has a hypoechoic appearance with an irregular border separating it from normal aerated lung (shred sign). A parapneumonic effusion frequently is also present that may be anechoic, echogenic, and/or septated.

Air bronchograms were first reported on chest radiography by Fleischner in 1948 and typically are considered to be reassuring to the clinician that the bronchus is patent. An equivalent sonographic finding of “linear, high-amplitude branching echoes that converge toward the lung root” was identified in 1986 and was incorporated into the standardized sonographic findings of alveolar consolidation. Further evaluation of these branching echoes established that they could be static (no movement with respiration) or dynamic (appearing on inspiration and disappearing on expiration). Lichtenstein et al found that the dynamic air bronchogram was poorly sensitive but highly specific for nonobstructive pneumonia consolidation vs obstructive atelectasis. Static air bronchograms were seen in one-third of pneumonia cases and almost all with an obstructed airway on bronchoscopy. Therefore, the presence of a dynamic air bronchogram almost entirely excludes endobronchial obstruction as a cause for consolidation or atelectasis. Complete absence of air bronchograms can occur in pneumonia but should raise suspicion of obstructive atelectasis/consolidation rather than simple consolidation.

The fluid bronchogram appears sonographically as branching hypoechoic areas within the lobe, representing fluid-filled bronchi. First described in 1986 by Dorne, this finding was originally used to differentiate consolidated lung from pleural masses or pleural-based thoracic cancer, which would be expected to deform the branching airways. It has now been shown that the presence of fluid bronchograms is suggestive of consolidation resulting from an obstructed airway. Fluid bronchograms have been shown to be a useful sign of airway obstruction on CT imaging also but require contrast enhancement to be seen clearly. Although fluid bronchograms were demonstrated in 20% of pediatric patients with pneumonia in one study, this finding was not demonstrated in any patient in two adult studies that assessed sonographic findings of pneumonia in a combined total of 176 patients. Both studies identified air bronchograms in most patients.

Last, the lung edge in pneumonia is usually rounded and exhibits the shred sign. In compressive atelectasis, the atelectatic lung usually has one convex edge and one concave edge, in the shape of a sickle. The authors noted with interest the presence of a double concave lung edge in this case, which is a finding that is unreported to date but is anecdotally recognized to be suggestive of resorptive atelectasis. Further research to evaluate whether this is a true sign of obstructive pneumonia is required.

This case highlights the importance of recognition of these ultrasound findings in cases of pneumonia that should alert the clinician to the possibility of endobronchial obstruction and trigger further investigations that include CT scanning and bronchoscopy.

Reverberations
1. Thoracic ultrasound scanning is very useful as a noninvasive, nonirradiating point of care examination to evaluate lung parenchymal abnormalities, in addition to parapneumonic pleural effusion, in patients with pneumonia.
2. Early pneumonia is characterized by increased B-lines; dense consolidation is characterized by normal vasculature, dynamic air bronchograms, and the shred sign.
3. The absence of dynamic air bronchogram, the presence of fluid bronchograms, and possibly, the double

Figure 5 – ⁶⁸Ga-DOTA octreotate PET/CT scanning shows intensely octreotate-avid rounded lesion with postobstruction consolidation.
concave lung edge should alert the physician to the possibility of a postobstructive pneumonia/atelectasis.

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Additional information: To analyze this case with the videos, see the online version of this article.

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