Assessment of lung parenchymal pathology

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AIMS

- Knowledge of B-lines, interstitial syndrome and its causes
- Knowledge of typical lung ultrasound (LUS) patterns seen in different types of lung parenchymal pathology
- Knowledge of clinical impact when using LUS as a part of whole-body ultrasound

SUMMARY

The B-line and interstitial syndrome

The B-line

The presence of a characteristic artefact known as a B-line can be used as an indirect marker of lung disease. B-line artefacts occur when the density of the lung has increased as for example in interstitial oedema or pulmonary fibrosis. The ultrasonic waves are believed to cause resonance in the lung interstitium with increased density. This continuing echo-signal appears on the screen as a strong hyperechoic, laser-like, vertical line from the pleura and extend to the bottom of the field of view and moves synchronously with lung sliding (1).

Interstitial syndrome

Multiple B-lines can in some diseases be seen almost universally when scanning both lungs. This finding is often referred to as the interstitial syndrome (IS). Many conditions that universally increase the density of the lungs have been described to cause universally multiple B-lines and therefore the interstitial syndrome (e.g. pulmonary edema, interstitial lung disease, pneumonia, ARDS)(1).

Cardiogenic pulmonary edema

In an emergency department, the by far most common cause for interstitial syndrome is cardiogenic pulmonary edema. Hence, in this setting FLUS with signs of interstitial syndrome, one should suspect cardiogenic pulmonary edema. In a large multicenter study the diagnostic accuracy of LUS for the diagnosis of cardiogenic pulmonary edema was excellent with a sensitivity and specificity of 97% (95%CI 95-98.3%) and 97.4% (95%CI 95.7-98.6), respectively(2).

Interstitial lung diseases

In comparison to cardiogenic pulmonary edema, fewer studies have assessed the use of LUS for interstitial lung diseases (ILD). Generally, in ILD with a dominant ground-glass opacities pattern on HRCT, LUS can identify multiple B-lines and interstitial syndrome if the ground-glass opacities are diffuse. In ILD with a honeycombing pattern on HRTC, the visceral pleura appear thickened and fragmented in affected areas and B-lines are also present. LUS cannot be used to rule out ILD, as LUS findings can be normal even though substantial interstitial changes are present(3-5).
Lung parenchymal pathology

US can rule-in lung parenchymal pathology, but since LUS cannot visualize the entire lung surface and lung parenchymal pathology does not necessarily “touch” the pleura, LUS cannot rule-out conditions affecting lung parenchyma. Thus, LUS can accurately diagnose pneumonia, pulmonary embolism, lung contusion and lung / pleural tumour, but a normal LUS cannot exclude the presence of any of these conditions. LUS can however still detect lung parenchymal pathology with a high sensitivity and exhibit good correlation with computed tomography(6).

Lung parenchymal pathology patterns

Using the different sonomorphologic patterns LUS allows the clinician to differentiate between different causes of lung parenchymal pathology:
- Lung consolidation (pneumonia, pulmonary embolism, contusion)
- Lung atelectasis (compression, obstruction)
- Lung tumor
- Uncharacteristic lung parenchymal pathology

Pneumonia

The characteristic ultrasonographic appearance of pneumonia is a diffusely demarcated, hypoechoic lung consolidation. Visible air bronchograms within the consolidation is a very characteristic finding of pneumonic lung consolidation, typically not seen in the other causes of lung consolidation. The air bronchograms are seen as punctuate or linear hyperechoic structures within the lung consolidation(7). In a metaanalysis the sensitivity and specificity when using LUS to diagnose community acquired pneumonia were 94% (95%CI 92-96%) and 96% (94-97%), respectively(8).

Pulmonary embolism

The consolidation typically is a hypoechoic, triangular / round, well demarcated area of lung consolidation, varying from millimetres to several centimetres in size. The average patient with pulmonary embolism has 2-3 visible lung consolidations and often a pleural effusion(9). A meta-analysis of LUS’ diagnostic capabilities in the diagnosis of pulmonary embolism showed a pooled sensitivity and specificity of 80 % (95 % CI: 75 %, 83 %) and 93 % (95 % CI: 89 %, 96 %), respectively(10).

Atelectasis

In atelectasis, the lung tissue is completely airless. The characteristic finding on ultrasonography of atelectasis is a homogenous, sharply demarcated hypoechoic lung consolidation. In comparison with pneumonia, no air bronchograms are visible. LUS can be used to differentiate between an atelectasis caused by compression of the lung tissue (compression atelectasis) and an atelectasis caused by complete obstruction of the airways with subsequent replacement of air with fluid in the lung tissue distal to the obstruction (obstruction atelectasis)(11).

Tumor

Tumour appearance on ultrasonography varies considerably. Most often they are seen as a hypoechoic structure, but isoechoic and hyperechoic tumours has also been described. Tumours can also have an inhomogeneous appearance with mixture of hypo-, iso- and hyperechoic areas. The tumours may both be relatively well demarcated or diffusely demarcated. Necrosis of the tumour may be visualized using LUS(12).
Uncharacteristic lung parenchymal pathology

The sonomorphologic appearance of lung parenchymal pathology does not always fit into one of the patterns described above. More specialised forms of lung ultrasound with the use of Doppler, Power Doppler, Spectral Analysis and contrast enhanced ultrasonography (CEUS) may be of help in order to establish the type of lung consolidation.

Whole-body US and clinical impact

A whole-body US approach in which several anatomical structures are assessed by the use of focused US has been adopted in several scanning protocols(13-15). In patients admitted with respiratory symptoms, it seems that focused lung US should be combined with especially focused cardiac US and limited compression ultrasonography of the deep veins(15-18). The use of whole-body US in patients with respiratory symptoms has been shown to be able to provide the clinician with critical clinical information. In a study assessing the possibly impact of focused US on the initial clinical assessment, focused US could identify a potential life-threatening condition missed by clinical assessment in approximately every 7th patient scanned. The routine use of whole-body US in patients with respiratory symptoms has been assessed in a randomized clinical trial. Whole-body US in combination with standard diagnostics was compared with standard diagnostics alone for establishing correct diagnoses within the first 4 hours after ED admission. In the whole-body US group a significantly larger proportion of patients received correct diagnoses 4 hours after ED admission, with an absolute increase in correctly diagnosed patients of 24.3%. Additionally, there was an absolute increase of 21.2% in the proportion of patients receiving appropriate treatment within 4 hours(16).

REFERENCES