Lung Ultrasound (LUS)

LUS is an ultrasound technique that is used to create an image of internal body structures LUNGS. Its aim is often to find a source of a disease or to exclude pathology.
LUS signs, either alone or combined with other point-of-care ultrasound techniques, are helpful in the diagnostic approach to patients with acute respiratory failure, circulatory shock or cardiac arrest.

LUS monitoring can be performed at the bedside and used in mechanically ventilated patients to assess the efficacy of treatments, to monitor the evolution of the respiratory disorder, and to help the weaning process. LUS can be used for early detection and management of respiratory complications under mechanical ventilation, such as pneumothorax, ventilator-associated pneumonia, atelectasis and pleural effusions.

When LUS can be **useful in ER**

- Pleural pathology
- Pericardial pathology
- Shortness of breath
- Cyanosis
- Cough
- Shock

Convex probe

Linear probe

Sector probe

Objectives

1. To show the diagnostic capabilities of Lung Ultrasound in Critical Care.
2. To illustrate the diagnostic modalities needed.
3. To highlight the fields of application.
4. To encourage the use of standardized protocols and terminology.

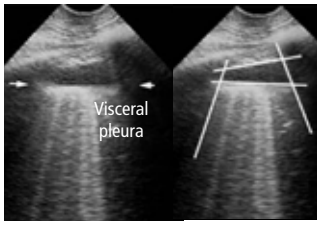
LUS **10 signs**

1. Bat sign (pleural line) 2. Lung sliding 3. A-line (horizontal artifact)	**NORMAL**
4. Quad sign 5. Sinusoid sign	**EFFUSION**
6. Fractal and tissue-like sign	**CONSOLIDATION**
7. B-line (vertical artifact) 8. Lung rockets	**INTERSTITIAL**
9. Abolished lung sliding with stratosphere sign 10. Lung point	**PNEUMOTORAX**

Two more signs, the lung pulse and dynamic air bronchogram, are used to distinguish atelectasis from pneumonia

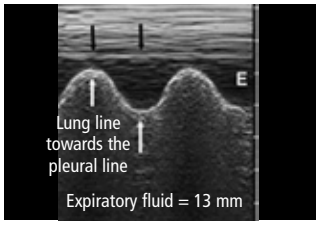
NORMAL Lung – A-line

The A-lines are horizontal artifactual repetitions of the pleural line displayed at regular intervals



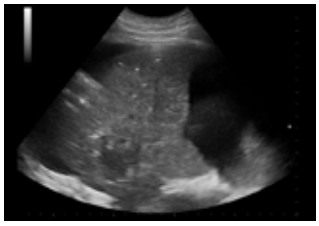
Pleural EFFUSION

Quad sign (2D LUS)



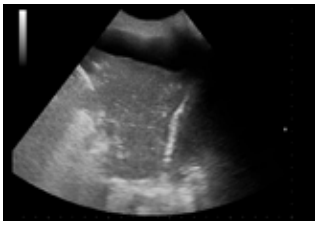
Pleural EFFUSION

Sinusoid sign (M-mode)

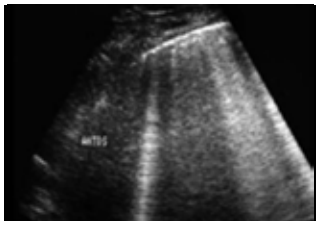


Lung CONSOLIDATION

Massive consolidation of the whole lower lobe without aerated lung tissue and no fractal sign

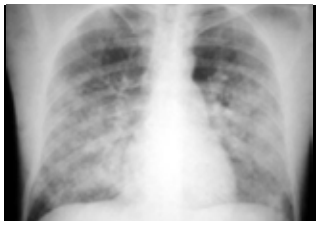


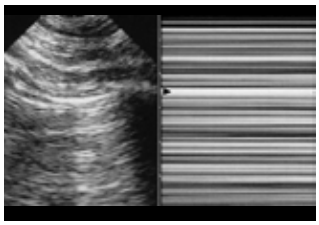
Middle lobe consolidation not invading the whole lobe, with fractal border with aerated lung



INTERSTITIAL Syndrome

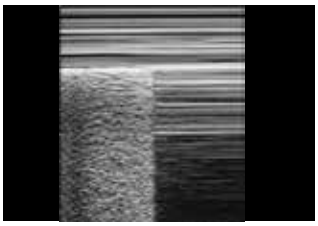
Pulmonary interstitial edema is designed by diffuse lung rockets. Lung rockets are defined as at least 3 B-lines between two ribs.





PNEUMOTORAX

Abolished lung sliding "stratosphere sign"



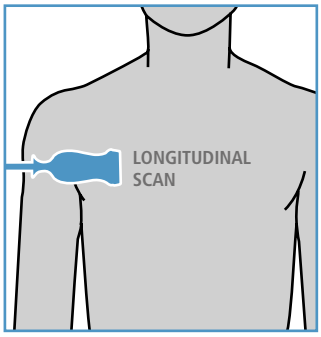
Anterior abolished lung sliding + A-lines

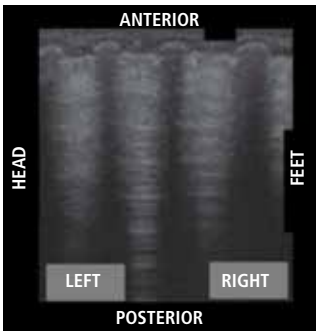
Lung point at the area at the junction between dead air (pneumothorax) and living air (inflating lung)

LUNGs approach **standardization**

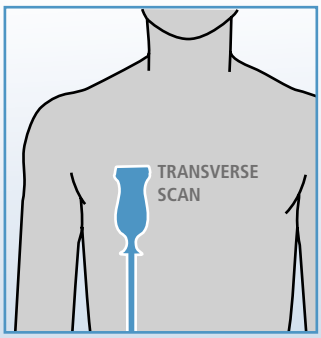
Examination technique

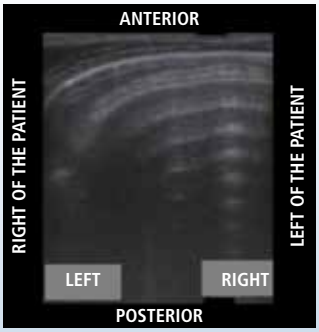
1. Patient in a semi-seated and sitting position for optimal access to posterior-basal lung segments.
2. Linear probe (7.5 -15 MHz) for study of pleural line and subpleural spaces
3. Convex probe (3.5 -5 MHz) for B-line evaluation, consolidations and collapses.
4. Color-Doppler module for assessing vascularization in consolidation
5. Appropriate application (abdomen or vascular) with lung preset
6. Correct general gain and TGC setting for better B-line representation
7. Bilateral lung multiscansions at conventional thoracic lines and between them (parasteral, emiclave, LAA, LAM, LAP) plus posterior scans (scapula angular and paravertebral)

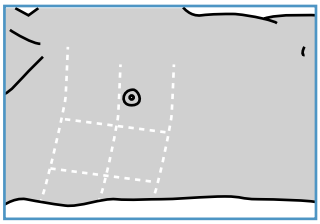


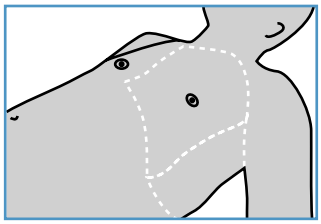


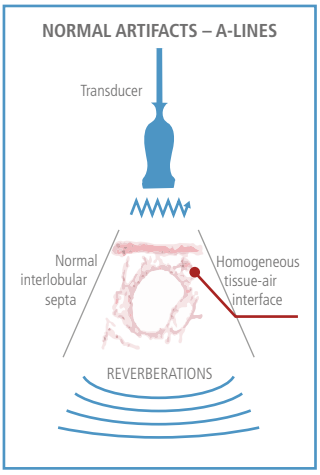
The longitudinal approach has the advantages of locating the pleural line in all circumstances.

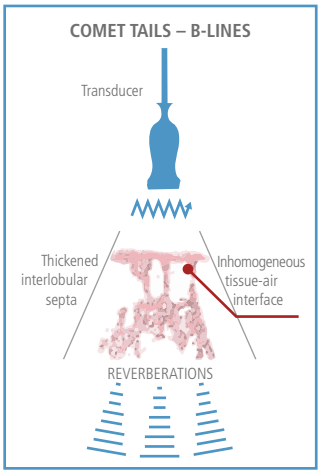


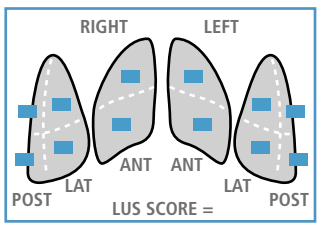


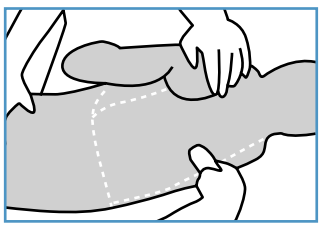


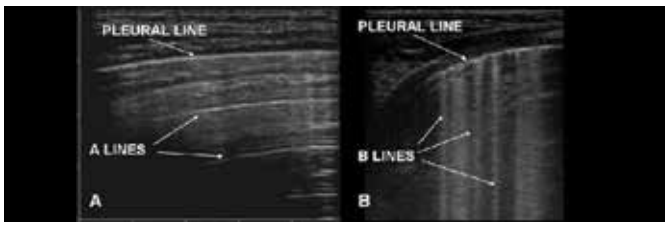


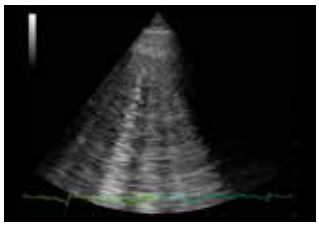








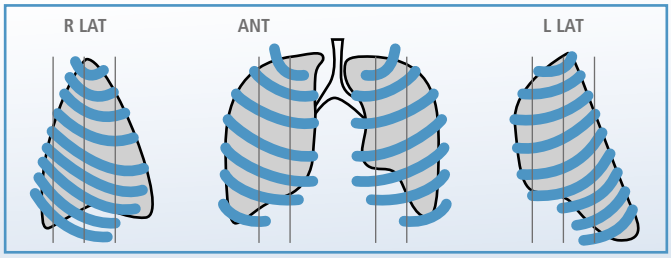


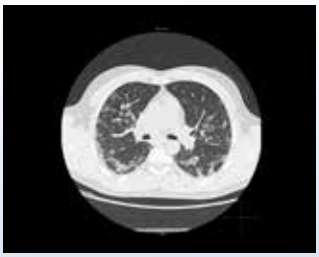


CT vs **LUS**

Lung CT	Lung ultrasound
Thickened pleura	Thickened pleural line
Ground glass shadow and effusion	B-lines (multifocal, discrete, or confluent)
Pulmonary infiltrating shadow	Confluent B-lines
Subpleural consolidation	Small (centomeric) consolidations
Translobar consolidation	Both non-translobar and translobar consolidation
Pleural effusion is rare	Pleural effusion is rare
More than two lobes affected	Multilobar distribution of abnormalities
Negative or atypical in lung CT images in the super-early stage, then diffuse scattered or ground glass shadow with the pregress of the disease, further lung consolidation	Focal B-lines are the main feature in the early stage and in mild infection; alveolar interstitial syndrome is the main feature in the progressive stage and in critical patients; A-lines can be found in the convalescence; pleural line thickening with uneven B-lines can be seen in patients with pulmonary fibrosis

The ultrasound bedside can read dynamically and constantly the air-fluid ratio which the CT scan cannot perform. Lung ultrasound is more sensitive than chest X-ray for the diagnosis of pneumothorax and shows similar high specificity





LUS provide significant information to improve the management of the critical patient under mechanical ventilation, from the initial assessment, through the ventilation setting and its complication diagnosis, until the weaning process.

1. Diagnosis and stage of patient candidates for intubation (forced ventilation)
2. Patient follow up (no CT scan)
3. Monitoring and adapt fan therapy effectively by avoiding pneumothorax. Rif (Emergency Ultrasound Guidelines 2008) ACEP The medical use of US for diagnostic evaluation of emergency conditions and diagnoses, resuscitation of the acutely ill, Critically ill or injured, guidance of high risk or difficult procedures, monitoring of certain pathologic states and as an adjunct to therapy.

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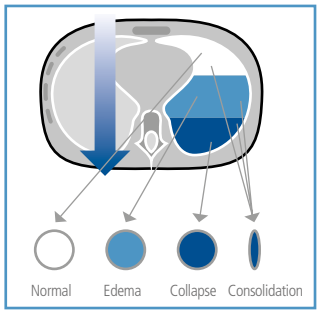
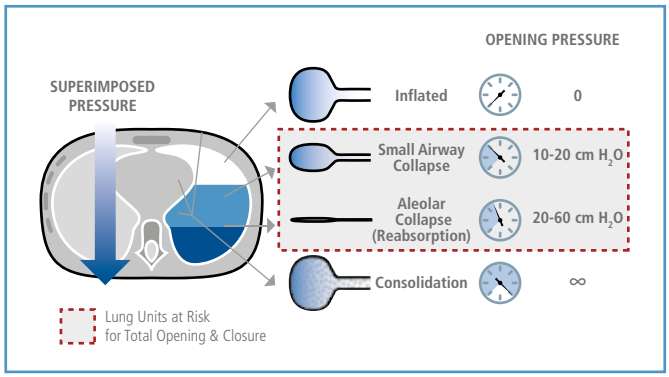


The most dorsal lung areas are the most compromised while the most sternal and ventral areas are less compromised.



LUS for monitoring mechanical ventilation

Pneumothorax can be a consequence of barotrauma, mainly when lung compliance is reduced. LUS is accurate in the diagnosis of pneumothorax (Lichtenstein et al. 2000) and is superior to supine anterior chest x-ray (Blaivas et al. 2005). The presence of real images (consolidation, effusion), of any pleural movement (sliding, lung pulse) or artefacts deriving from the visceral pleura (B-lines) rules out pneumothorax with 100% negative predictive value. If a static A pattern is visualized, a lung point must be searched moving the probe laterally and inferiorly: the lung point corresponds to the site where the collapsed lung goes back in touch with the parietal pleura and rules in pneumothorax with 100% positive predictive value. If no lung point is identified, the positive predictive value of a static A pattern alone ranges from 55 to 98%, depending on the clinical context; for example, if the lung is completely collapsed, no lung point can be visualised.

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Our best proposal for **LUS**

MyLab™ **OMEGA**

MyLab™ **SIGMA**

Complete	Fast	Compact	Connected
High performance in all the applications	2 probes connectors Up to 4 with multiconnector	Full screen mode	Follow-up & Multi-modality options to retrieve other imaging modalities
Large probes portfolio, convex, linear and phased-array	Touchscreen with intuitive menus	Swivelling monitor	eStreaming for real-time imaging streaming
Advanced configurations, including TE probe or Strain package	Long-duration battery and quick boot-up time (15")	Agile trolley easy with 4 swivelling wheels	eTablet & MyLab™Remote for remote storage and control

Low-frequency probe to scan lung parenchyma and commonly used in emergency for abdominal organs

High-frequency probe to scan pleural area and superficial structures. Commonly used to scan vessels and support lines' placement

Low-frequency phased-array probe to scan the lung and commonly used for heart functionality monitoring

Systems/transducers cleaning & disinfection

- Standard care involves handwashing or hand sanitization and use of sterile gloves.
- Droplet precautions include gown, gloves, headcover, facemask and eye shield.
- Airborne precautions add special masks (e.g. N-95 or N-99 respirator masks, or powered air purifying respirator - PAPR systems) and shoe covers.

Equipment care is critical in the prevention of transmission. Cover probes and machine consoles with disposable plastic and forego the use of ECG stickers. Echocardiogram machines and probes should be thoroughly cleaned, ideally in the patient's room and again in the hallway. Smaller, laptop-sized portable machines are more easily cleaned before and after the examination.

Scientific references

2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC). Developed with the special contribution of the Heart Failure Association (HFA) of the ESC Piotr Ponikowski, Adriaan A Voors, Stefan D Anker, Héctor Bueno, John G F Cleland, Andrew J S Coats, Volkmar Falk, José Ramón González-Juanatey, Veli-Pekka Harjola, Ewa A Jankowska, Mariell Jessup, Cecilia Linde, Petros Nihoyannopoulos, John T Parissis, Burkert Pieske, Jillian P Riley, Giuseppe M C Rosano, Luis M Ruilope, Frank Ruschitzka, Frans H Rutten, Peter van der Meer, ESC Scientific Document Group *European Heart Journal, Volume 37, Issue 27, 14 July 2016, Pages 2129–2200, https://doi.org/10.1093/eurheartj/ehw128*

The use of echocardiography in acute cardiovascular care: recommendations of the European Association of Cardiovascular Imaging and the Acute Cardiovascular Care Association. Lancellotti P, Price S, Edvardsen T, Cosyns B, Neskovic AN, Dulgheru R, Flachskampf FA, Hassager C, Pasquet A, Gargani L, Galderisi M, Cardim N, Haugaa KH, Ancion A, Zamorano JL, Donal E, Bueno H, Habib G *Eur Heart J Acute Cardiovasc Care. 2015 Feb;4(1):3-5. doi: 10.1177/2048872614568073. Epub 2015 Jan 29.*

Ultrasound-guided mechanical ventilation Francesco Mojoli

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