



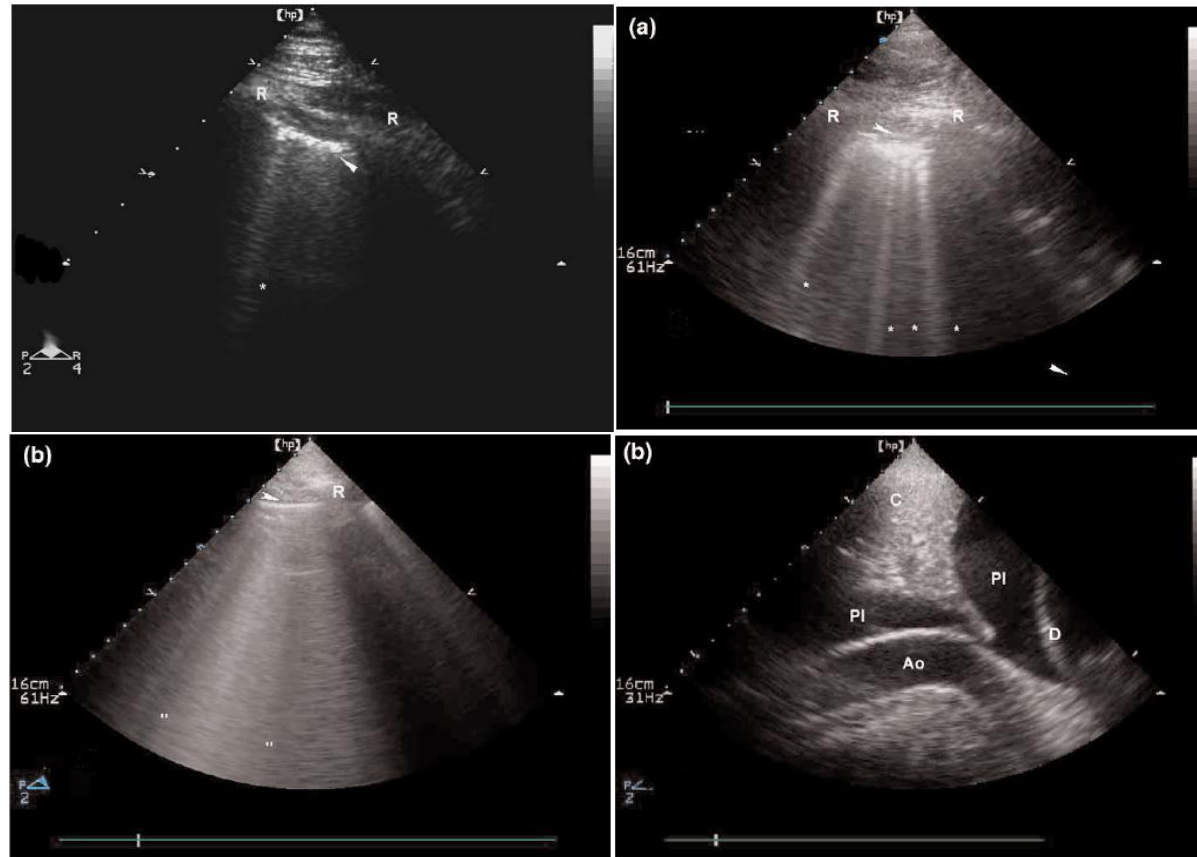
# Echographie Pulmonaires Généralités

Review

*Critical Care* 2007, 11:205 (doi:10.1186/cc5668)

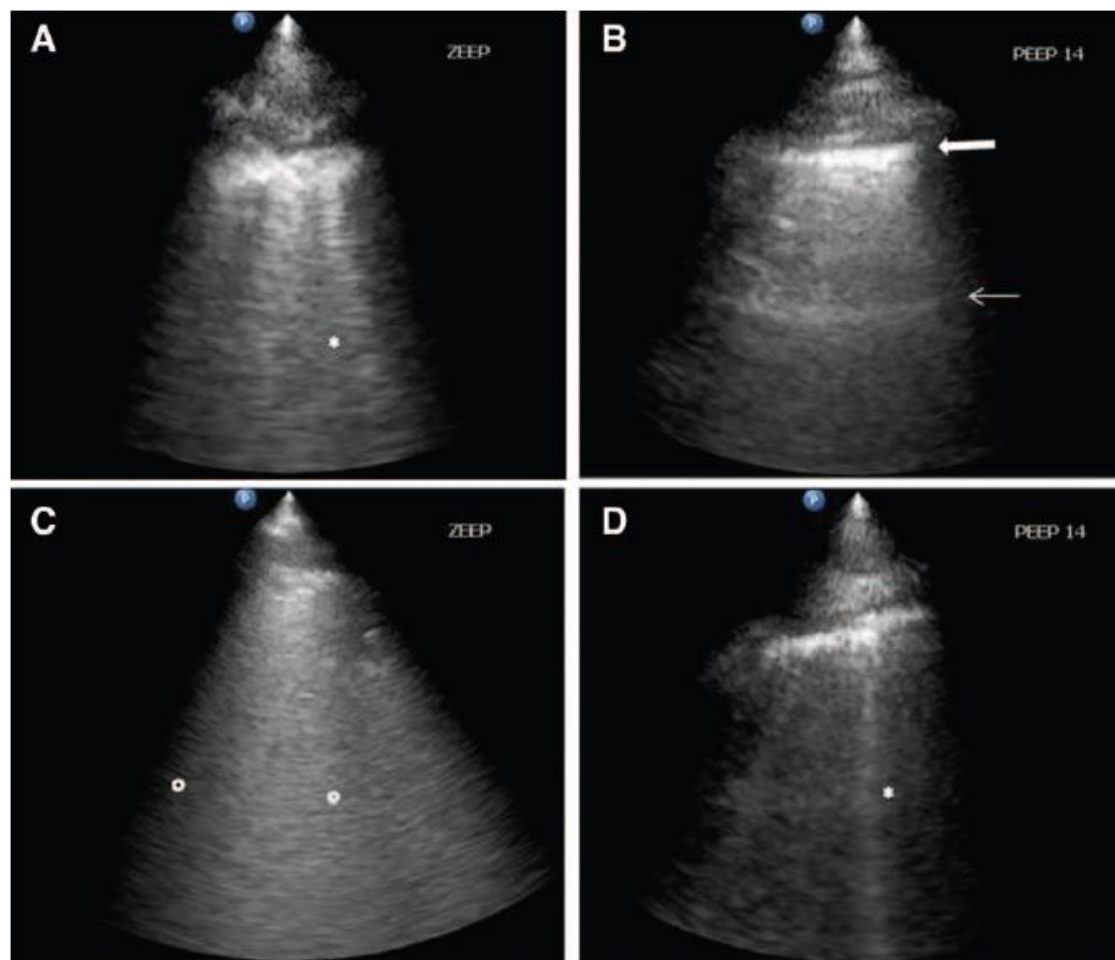
# Clinical review: Bedside lung ultrasound in critical care practice

Bélaïd Bouhemad<sup>1</sup>, Mao Zhang<sup>2</sup>, Qin Lu<sup>1</sup> and Jean-Jacques Rouby<sup>1</sup>



# Ultrasound for “Lung Monitoring” of Ventilated Patients

Belaïd Bouhemad, M.D., Ph.D., Silvia Mongodi, M.D., Gabriele Via, M.D., Isabelle Rouquette, M.D.



# American Journal of Respiratory and Critical Care Medicine

## CONCISE CLINICAL REVIEW



### Lung Ultrasound for Critically Ill Patients

Francesco Mojoli<sup>1,2</sup>, Bélaïd Bouhemad<sup>3,4</sup>, Silvia Mongodi<sup>2</sup>, and Daniel Lichtenstein<sup>5</sup>

<sup>1</sup>Department of Clinical-Surgical, Diagnostic, and Pediatric Sciences, Unit of Anaesthesia and Intensive Care, University of Pavia, Pavia, Italy; <sup>2</sup>Anestesia e Rianimazione I, Fondazione Istituto di Ricovero e Cura a Carattere Scientifico, Policlinico San Matteo, Pavia, Italy; <sup>3</sup>Dijon et Université Bourgogne Franche-Comté, Lipides Nutrition Cancer Unité Mixte de Recherche 866, Dijon, France; <sup>4</sup>Département d'Anesthésie et Réanimation, Centre Hospitalier Universitaire Dijon, Dijon, France; and <sup>5</sup>Medical Intensive Care

Am J Respir Crit Care Med Vol 199, Iss 6, pp 701-714, Mar 15, 2019

#### Abstract

Point-of-care ultrasound is increasingly used at the bedside to integrate the clinical assessment of the critically ill; in particular, lung ultrasound has greatly developed in the last decade. This review describes basic lung ultrasound signs and focuses on their applications in critical care. Lung semiotics are composed of artifacts (derived by air/tissue interface) and real images (i.e., effusions and consolidations), both providing significant information to identify the main acute respiratory disorders. Lung ultrasound 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. Moreover, a

semiquantification of lung aeration can be performed at the bedside and used in mechanically ventilated patients to guide positive end-expiratory pressure setting, assess the efficacy of treatments, monitor the evolution of the respiratory disorder, and help the weaning process. Finally, lung ultrasound can be used for early detection and management of respiratory complications under mechanical ventilation, such as pneumothorax, ventilator-associated pneumonia, atelectasis, and pleural effusions. Lung ultrasound is a useful diagnostic and monitoring tool that might in the near future become part of the basic knowledge of physicians caring for the critically ill patient.

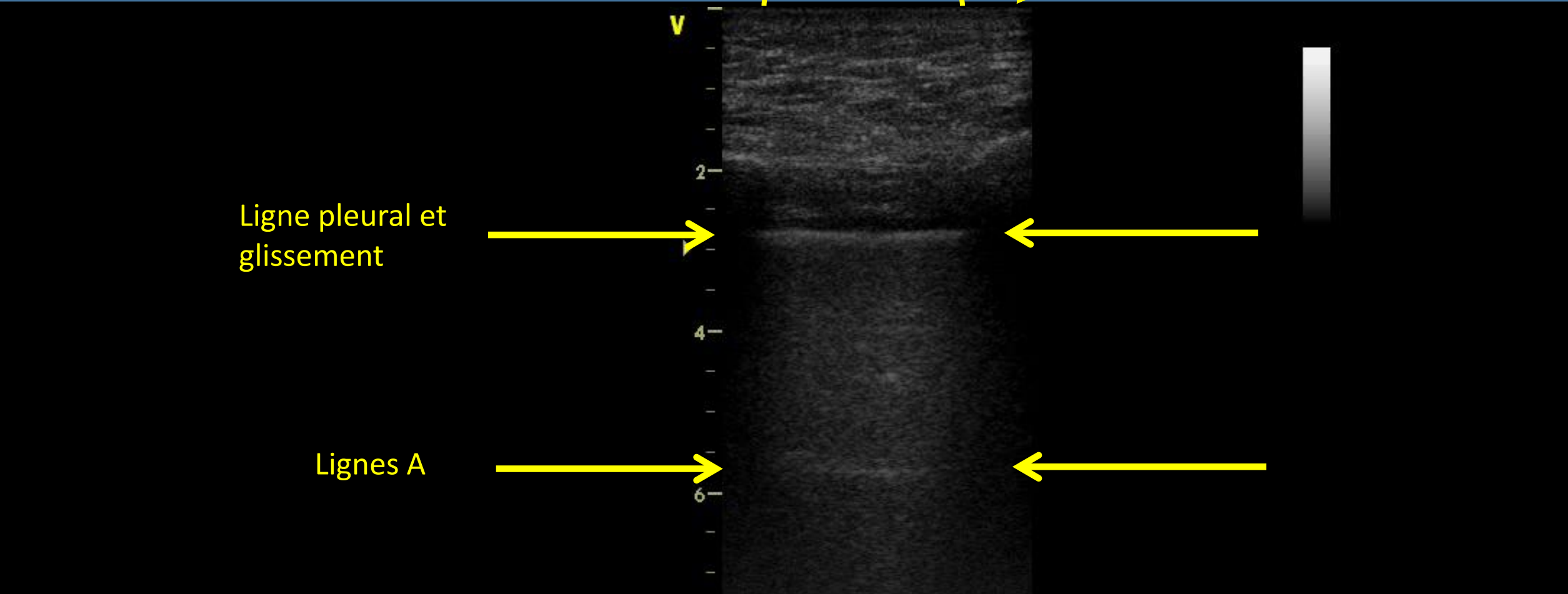
**Keywords:** thoracic ultrasound; mechanical ventilation; lung monitoring; acute respiratory failure

# Une sémiologie simple à apprendre!



# Glissement pleural et lignes A : aspect normal

côte Espace Intercostal côte



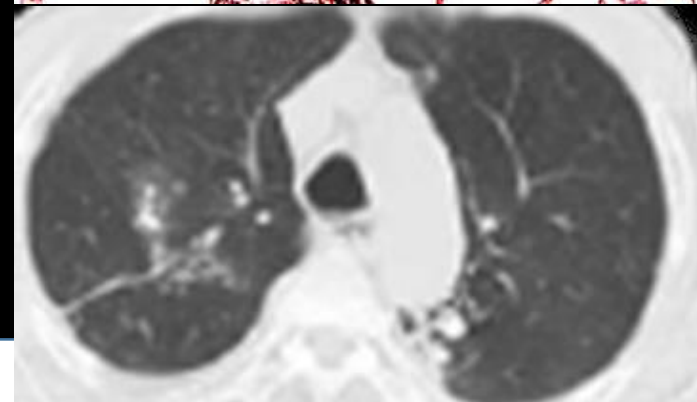
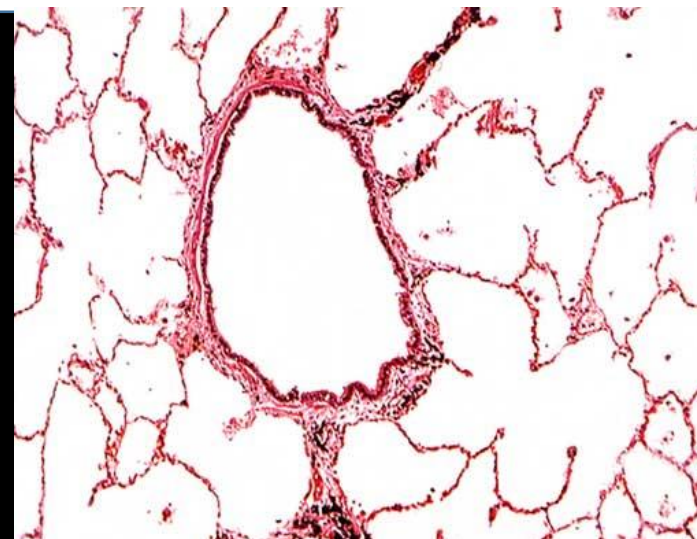
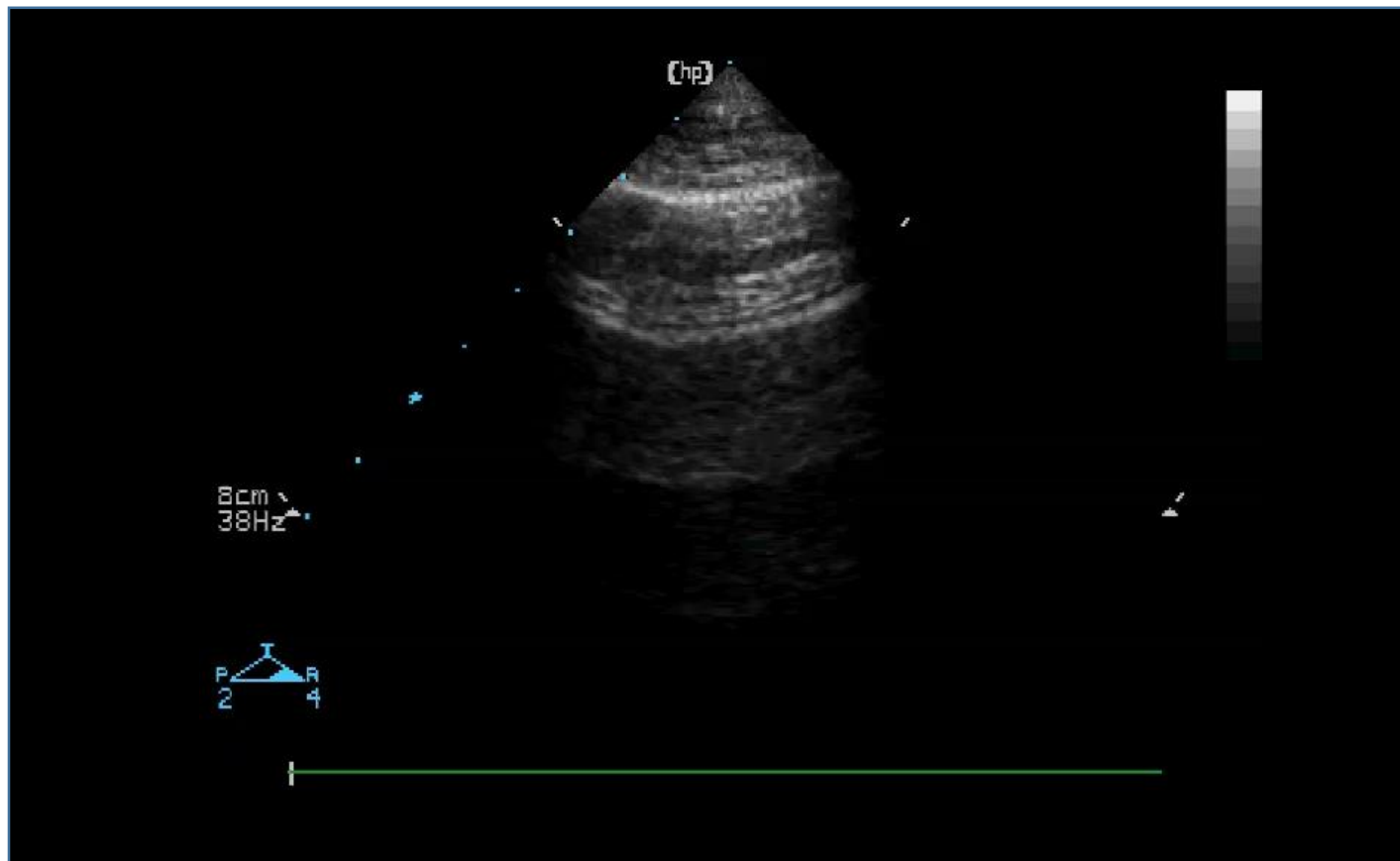
Ligne pleural et glissement

Lignes A



# Glissement pleural et lignes A : aspect normal

Ligne pleurale



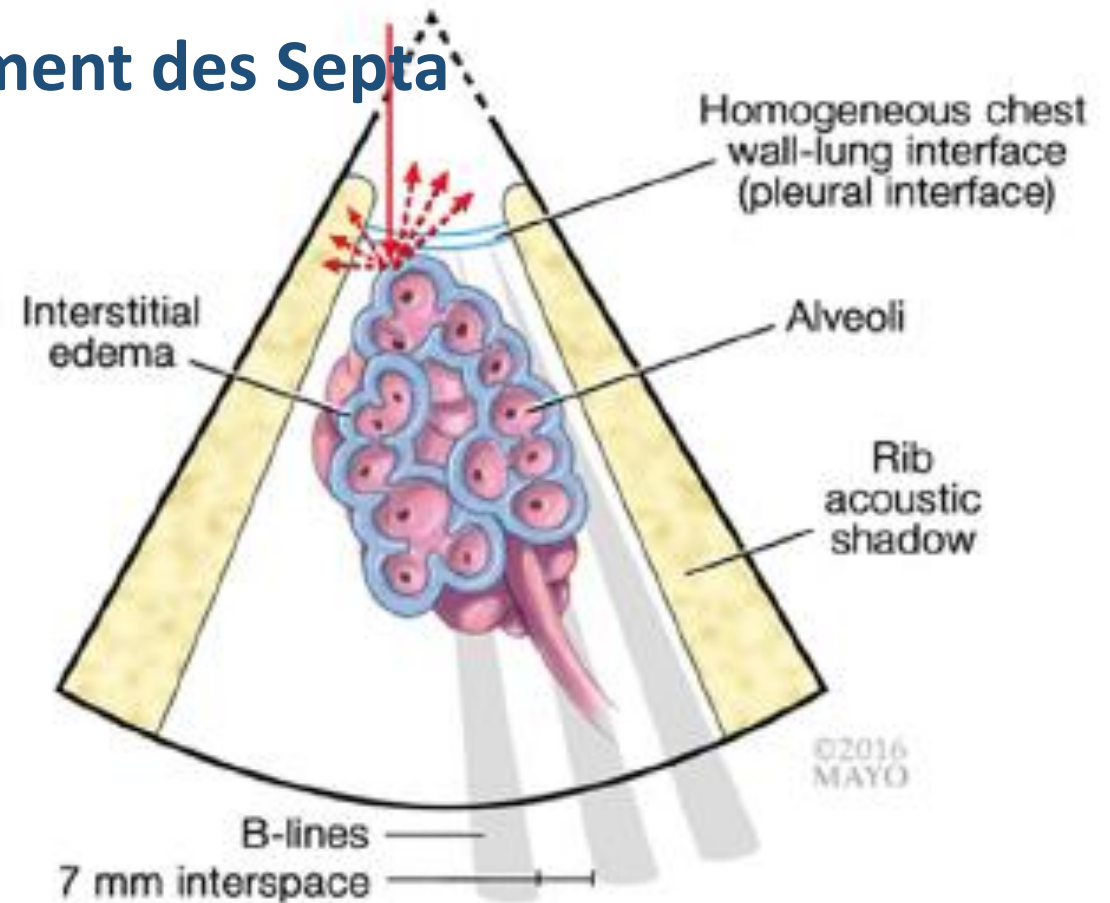
Glissement pleural + lignes A

# Syndrome interstitiel et lignes B

- **Syndrome interstitiel = Epaissement des Septa**

- **Lignes B : Lignes verticales, hyperéchoïques, effaçant les lignes A**  
-> jusqu'au bas de l'écran

**Lignes B espacées**

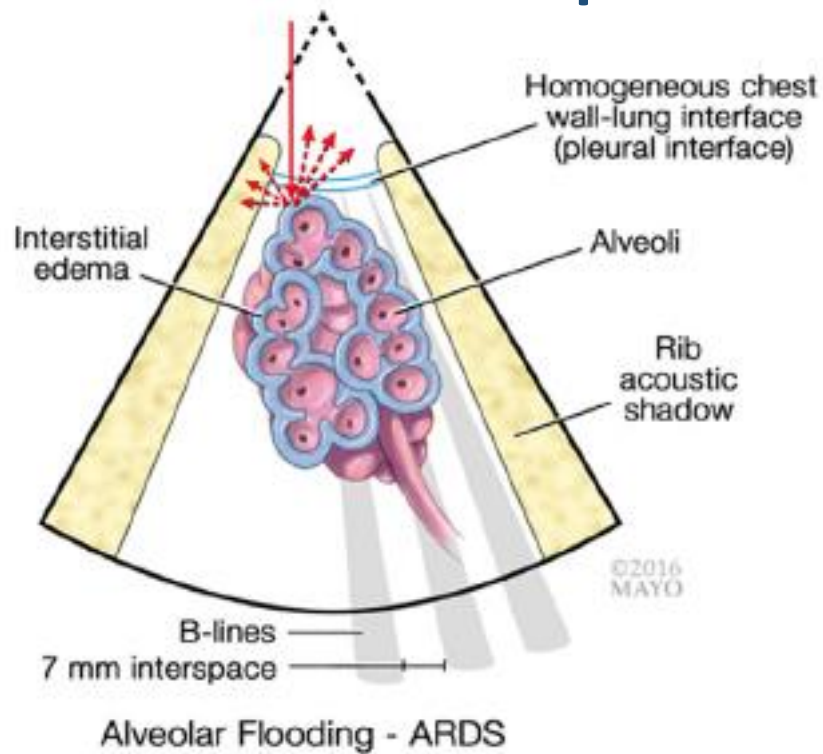


**Alveolar Flooding - ARDS**



# Syndrome interstitiel et lignes B

- **Syndrome interstitiel = Lignes B espacées**
- **Epaississement de septa**



# Syndrome interstitiel et lignes B

«lignes B espacées 7 mm

Epaississement des septa

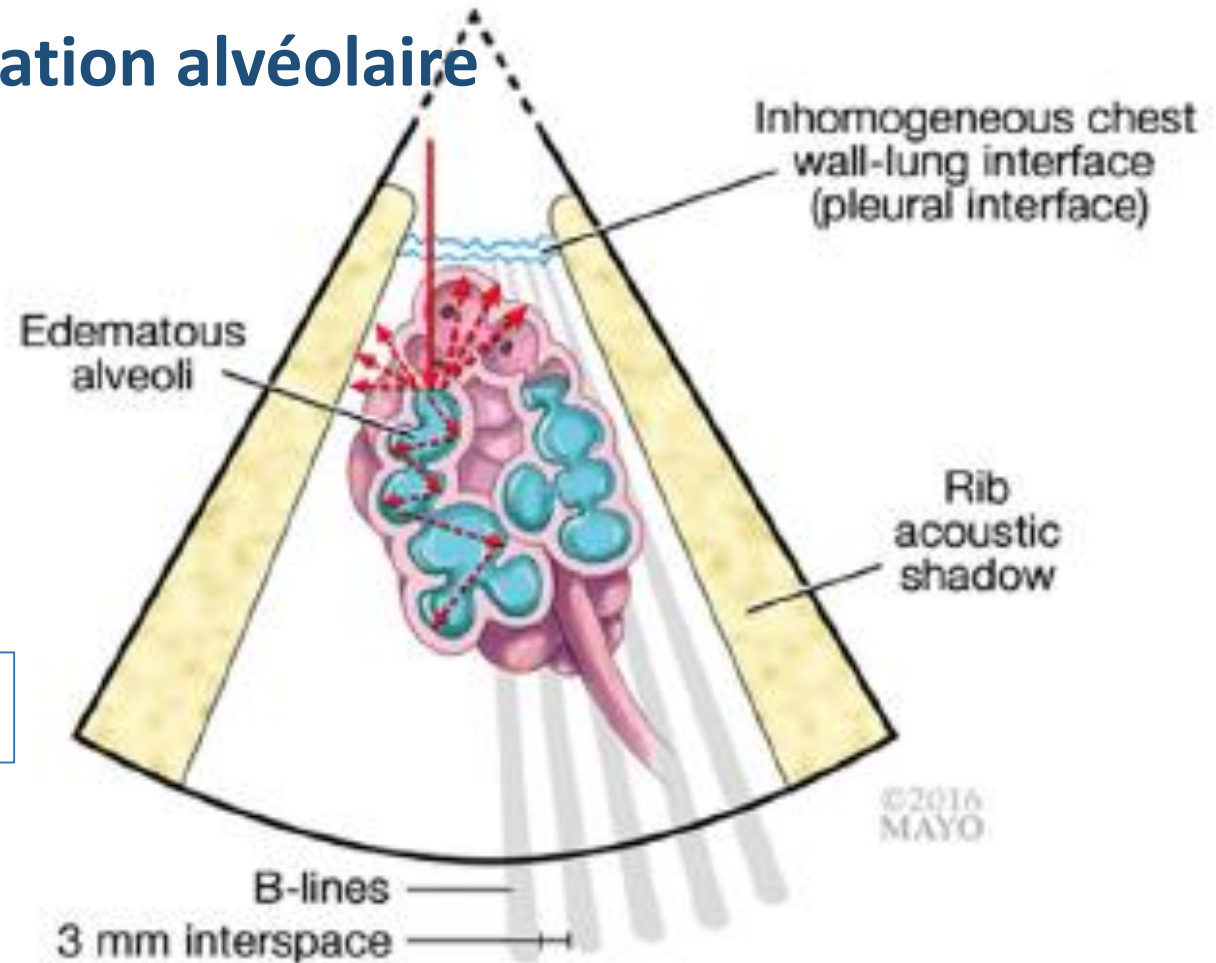


# Syndrome interstitiel et lignes B

- **Syndrome alvéolo interstitiel= inondation alvéolaire**

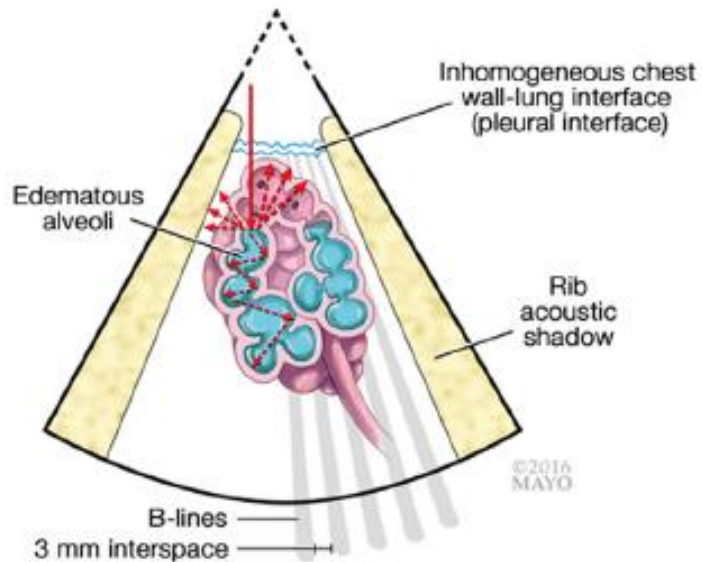
- **Lignes B: Lignes verticales, hyperéchoïques, effaçant les lignes A**  
-> jusqu'au bas de l'écran

**lignes B coalescentes**



# Syndrome interstitiel et lignes B

- **Syndrome alvéolo interstitiel = Lignes B coalescentes**
- **Oedème alvéolaire**



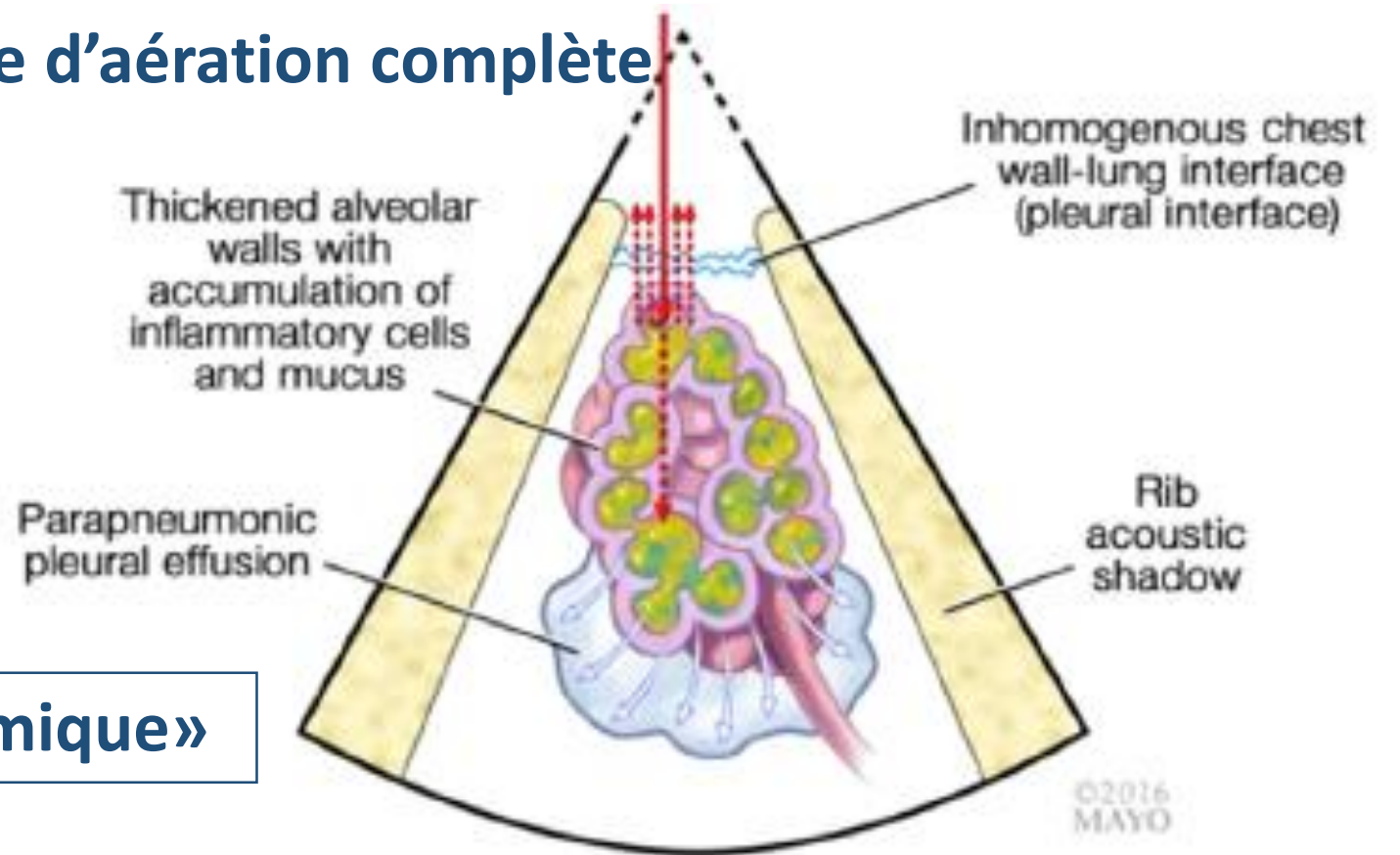


# Consolidation

- Comblement alvéolaire = Perte d'aération complète

-> structure tissulaire

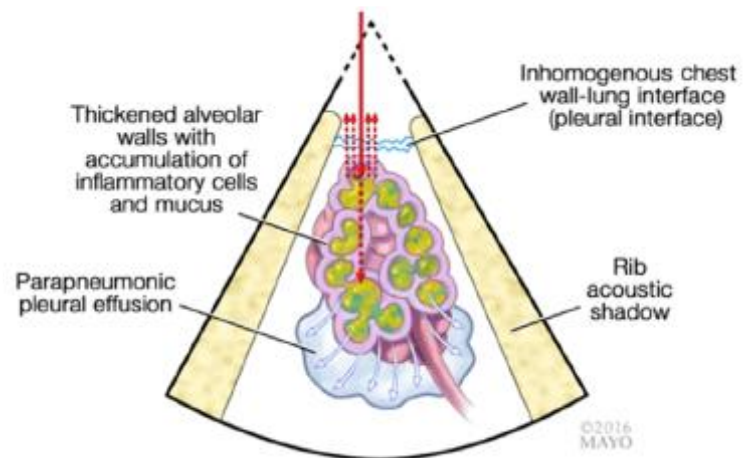
« bronchogramme aérien dynamique »





# Consolidation et Pneumonie

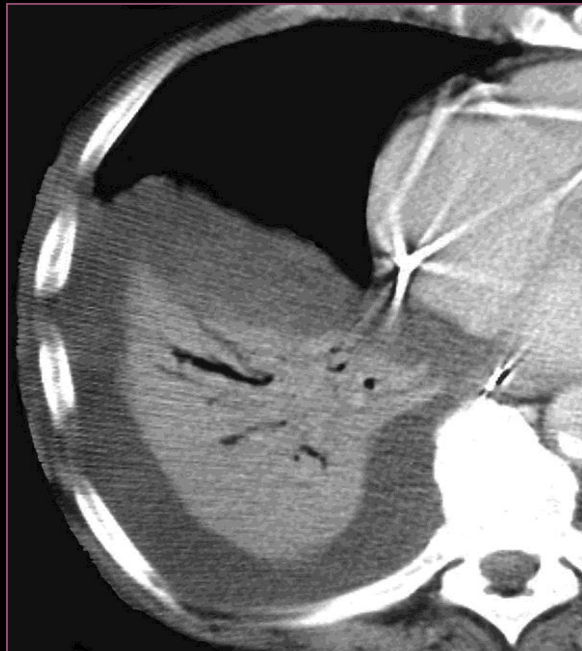
- Consolidation
- Bronchogramme aérien dynamique



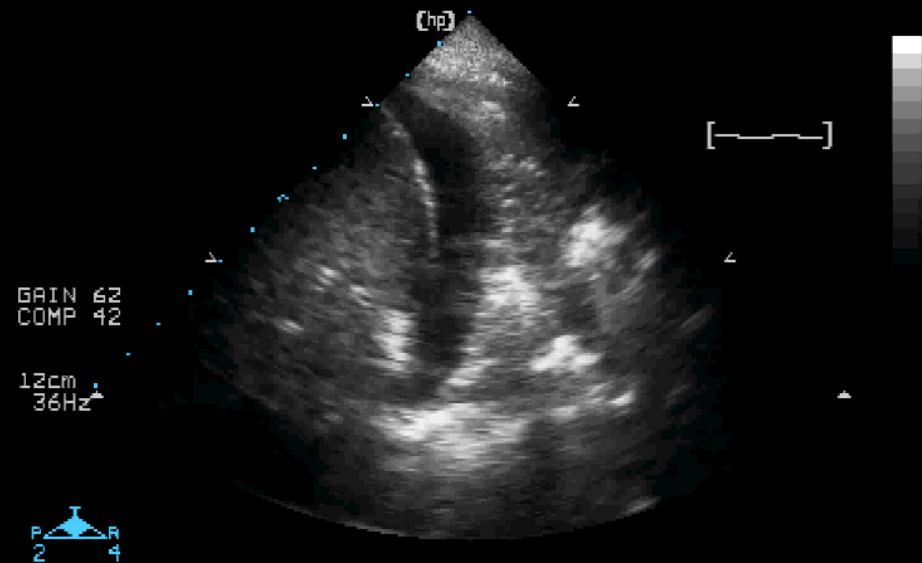
frontal view

# Consolidation et Pneumonie

- Consolidation
- Bronchogramme aérien dynamique



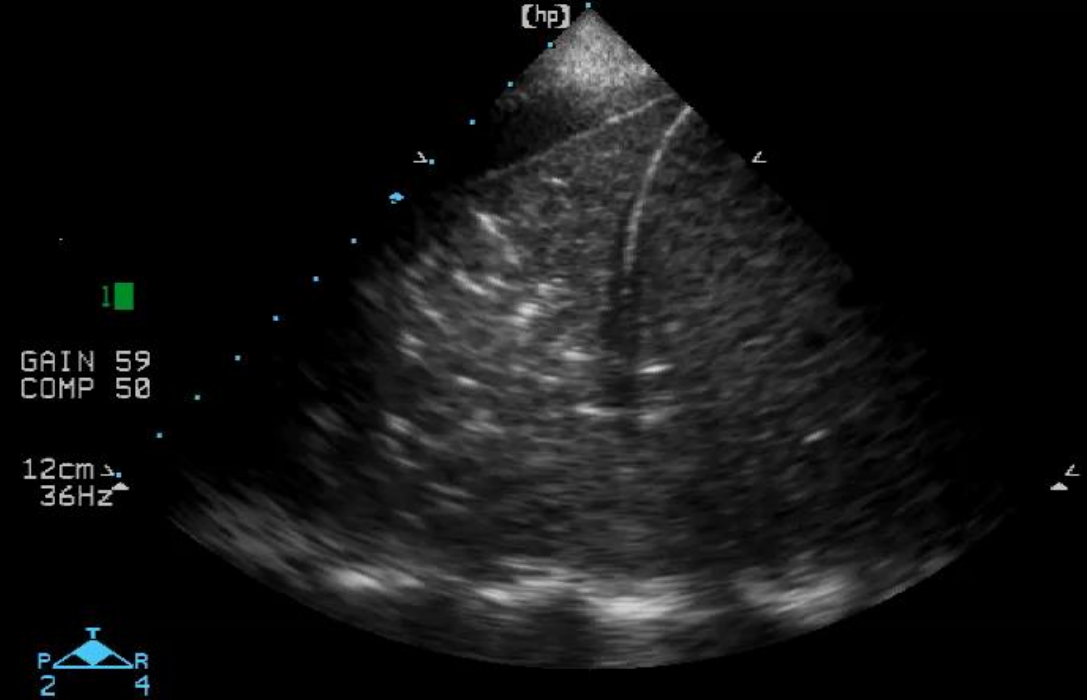
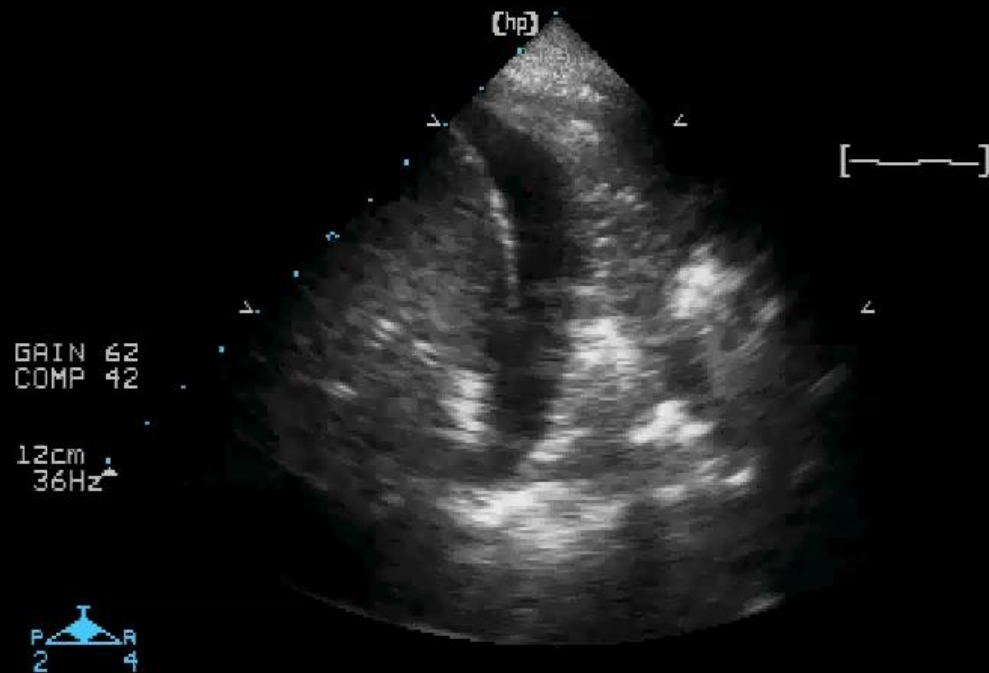
**Vue transversale**



**Vue grand axe**

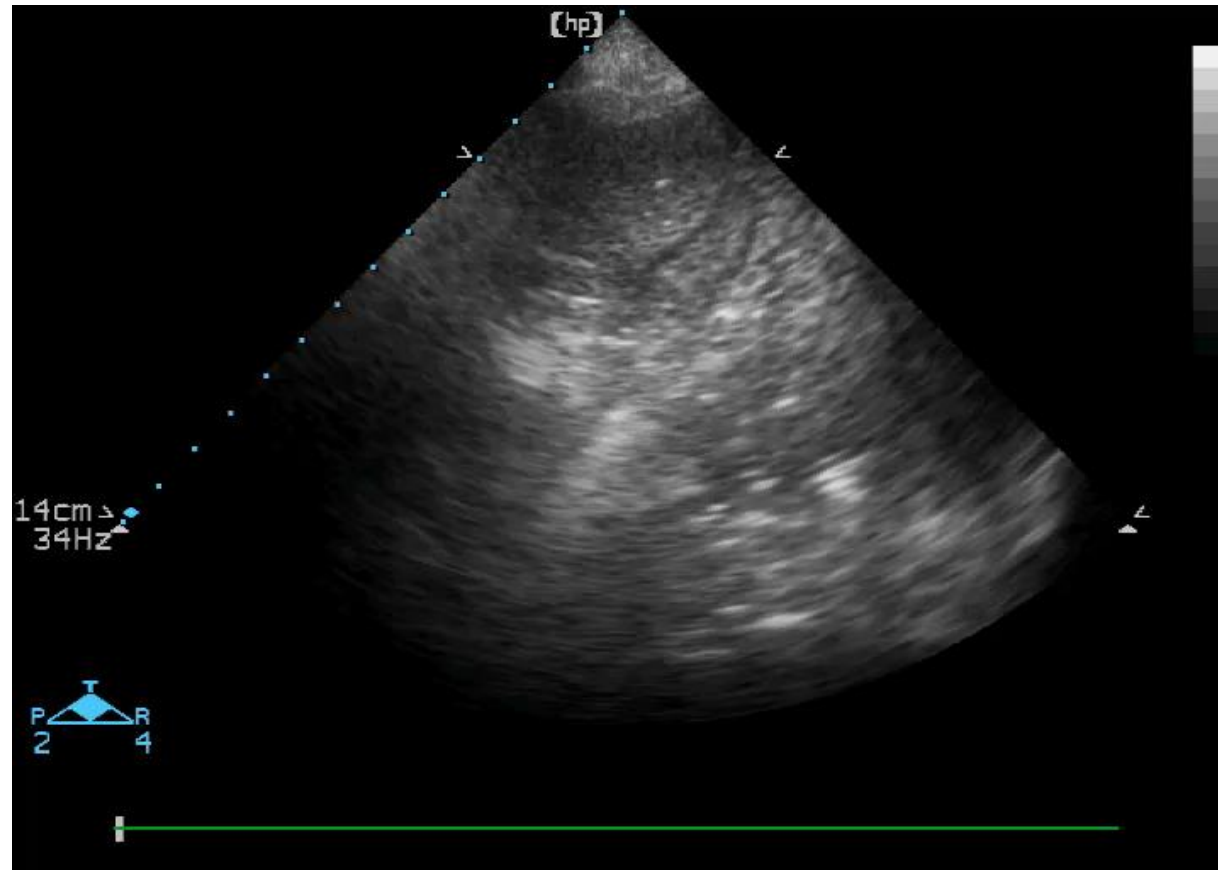
# Consolidation et Pneumonie

- Sévérité de la perte d'aération



# Consolidation

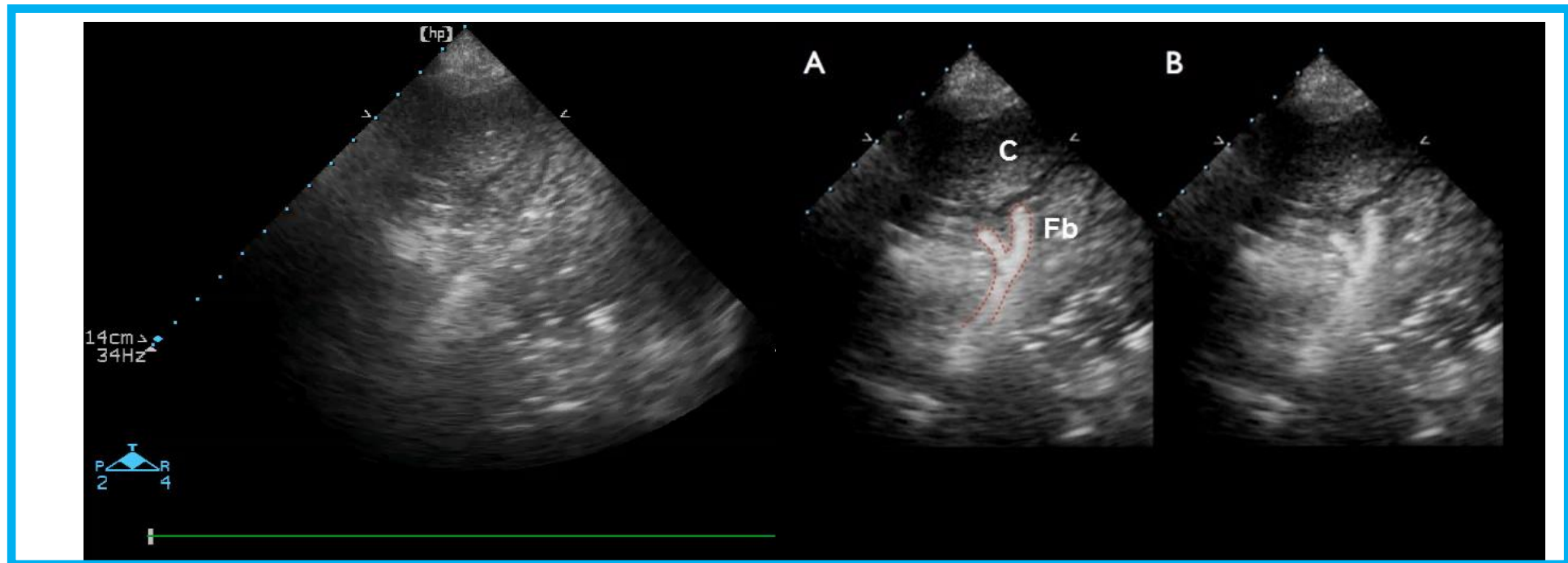
- Pneumonie: bronchogramme aérien dynamique “linéaire ou fluide”



D Lichtenstein, Chest 2009; 135:1421-5

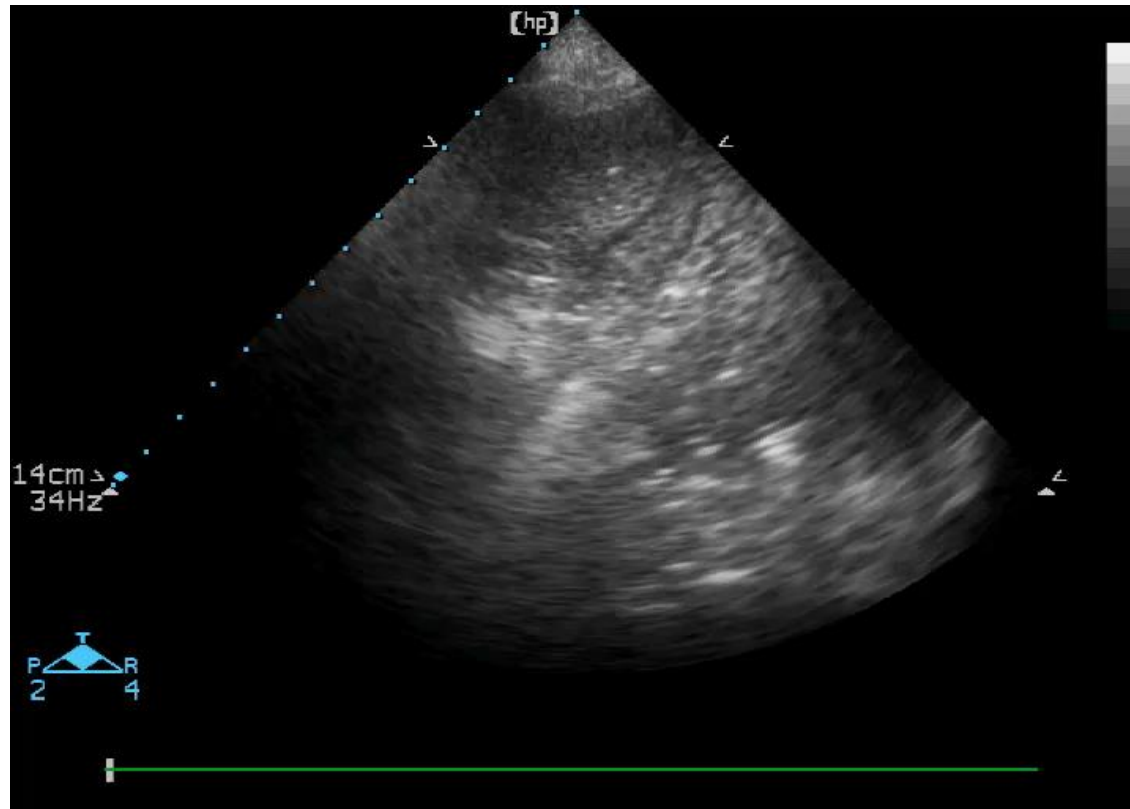
# Lung Ultrasound for VAP

The “linear “ or “ arborescent “air-bronchogram





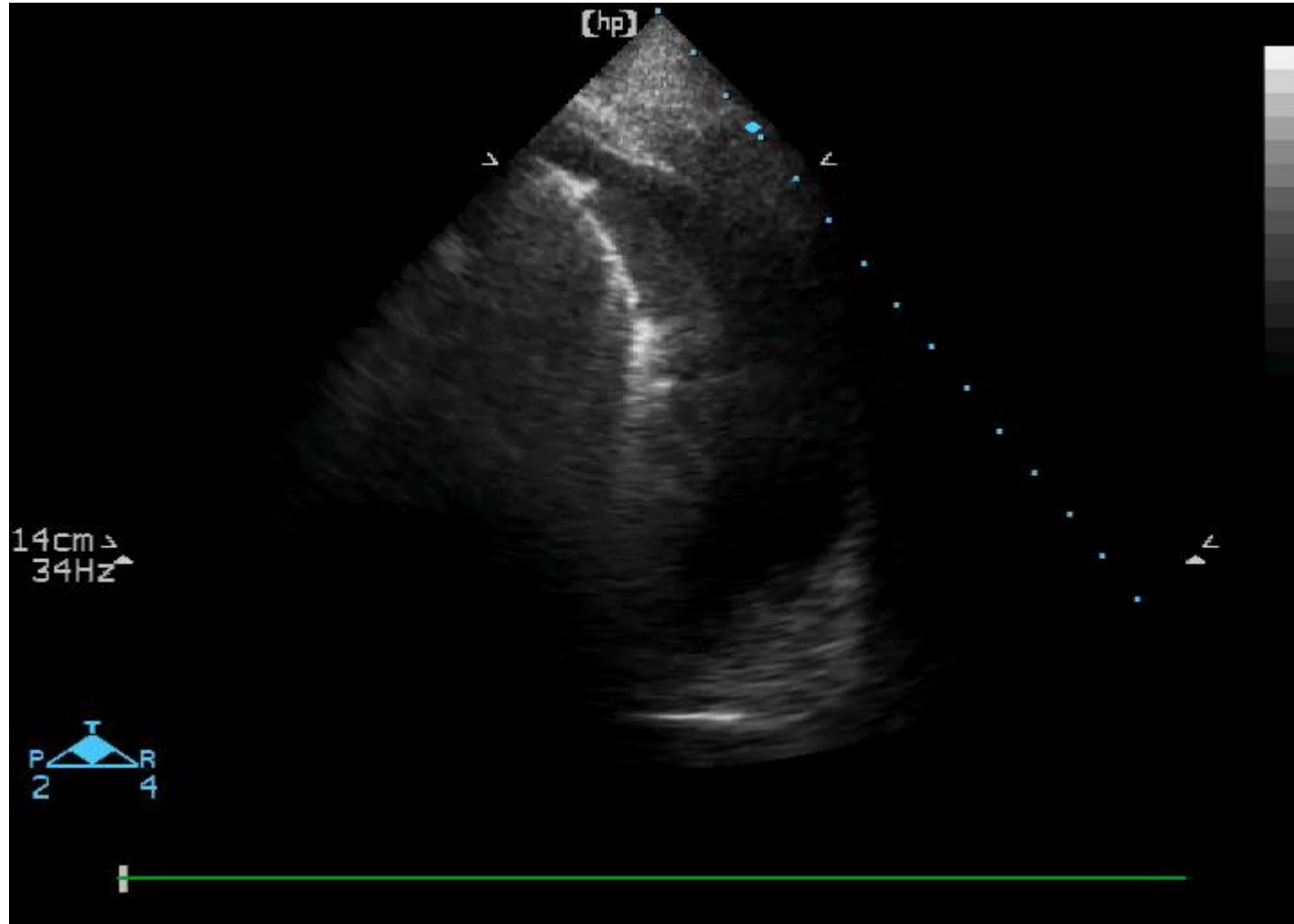
# Consolidation



D Lichtenstein, Chest 2009; 135:1421-5

# Consolidation

- Collapsus passif



# Consolidation

- Atélectasie “ostructive”



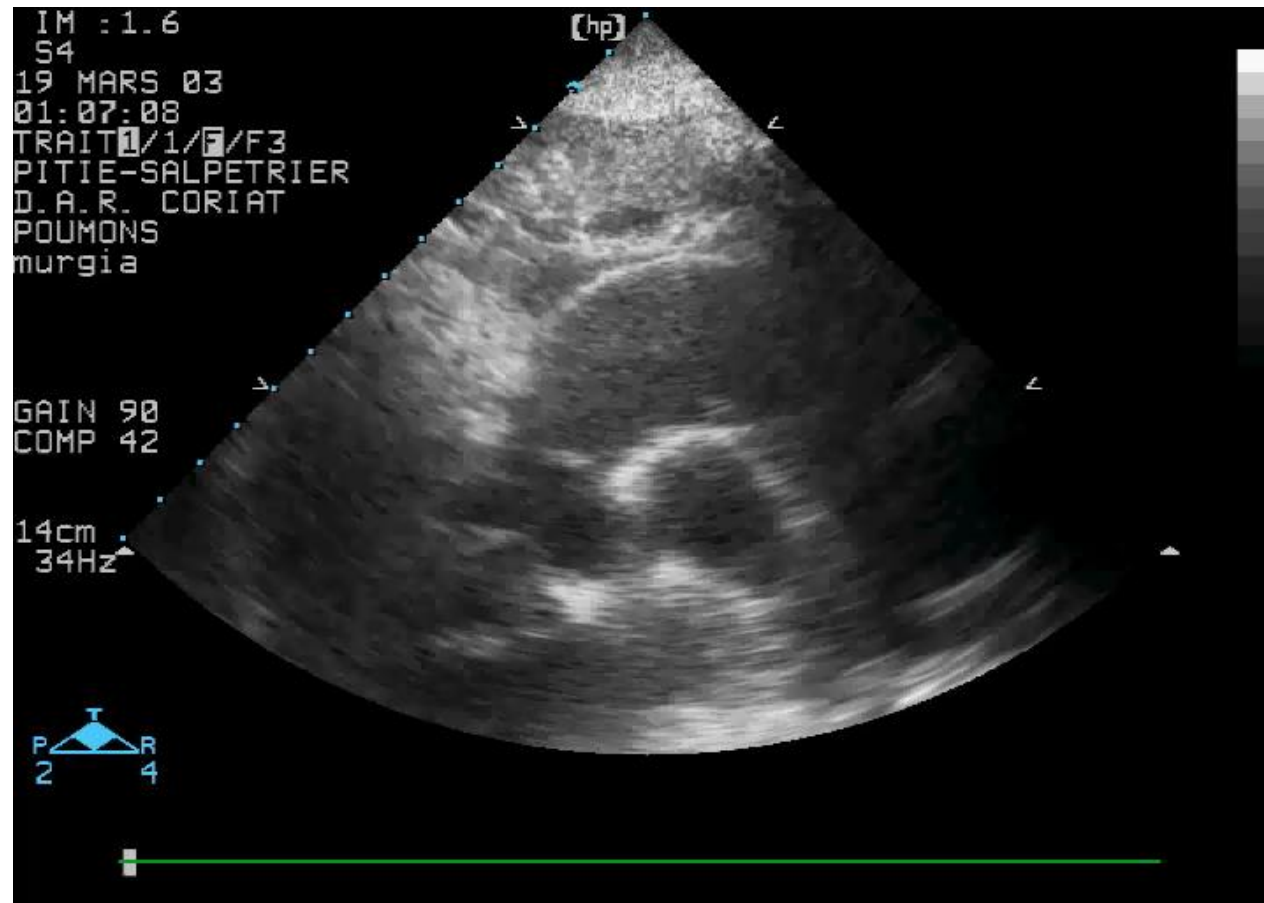
# Consolidation

- **Atélectasie**

Lobe supérieur gauche

- **Réduction du volume pulmonaire**

- **Syndrome rétractile**



# Consolidation

- **Atélectasie “compressive”**

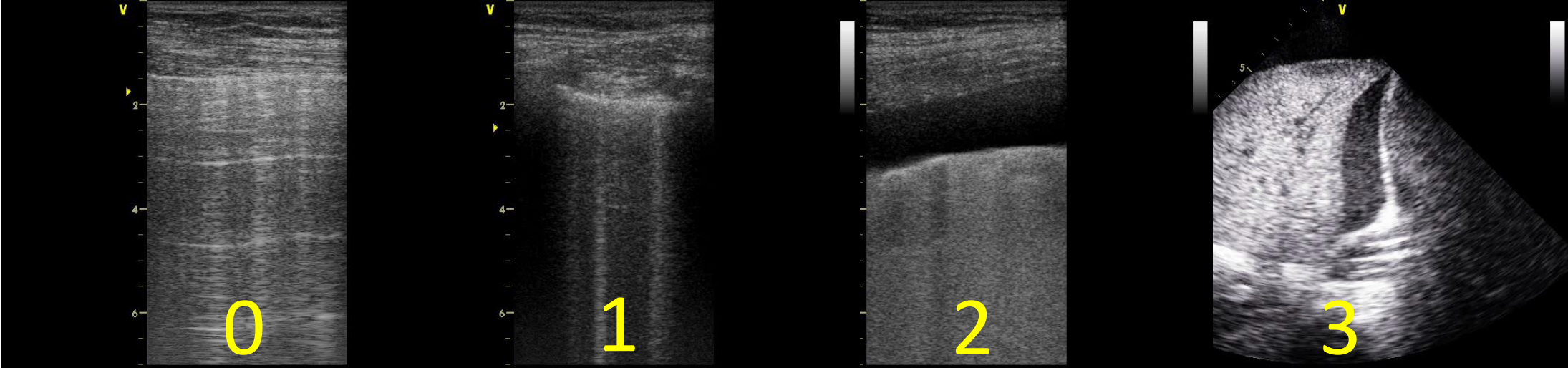
Aspect de « languette » pulmonaire et épanchement abondant



**Indication au drainage ?**



# Perte Progressive d'aération: Utilisation d'un score



Normal - A-lines

Non-Coalescent  
 $\geq 3$  B-lines

Coalescent B-lines

Consolidation

normal  
aeration

modérée  
Perte d'aération

sévère  
Perte d'aération

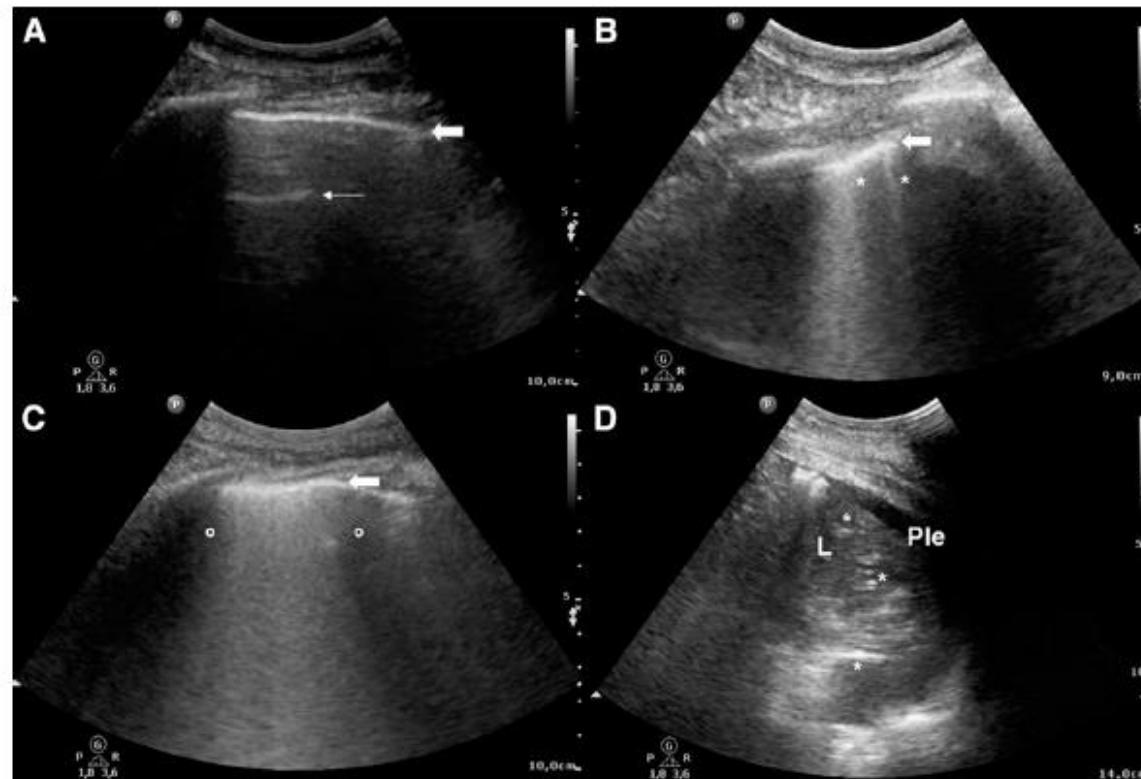
complète  
Perte d'aération



## Real-Time Visualization of Left Lung Consolidation Relief L Lung Ultrasound

Maxime Nguyen, Salima Benkhadra, Christophe Douguet, and Bélaïd Bouhemad

Service d'Anesthésie Réanimation, Centre Hospitalier Universitaire Dijon, Dijon, France



# IMAGES IN PULMONARY, CRITICAL CARE, SLEEP MEDICINE AND THE SCIENCES

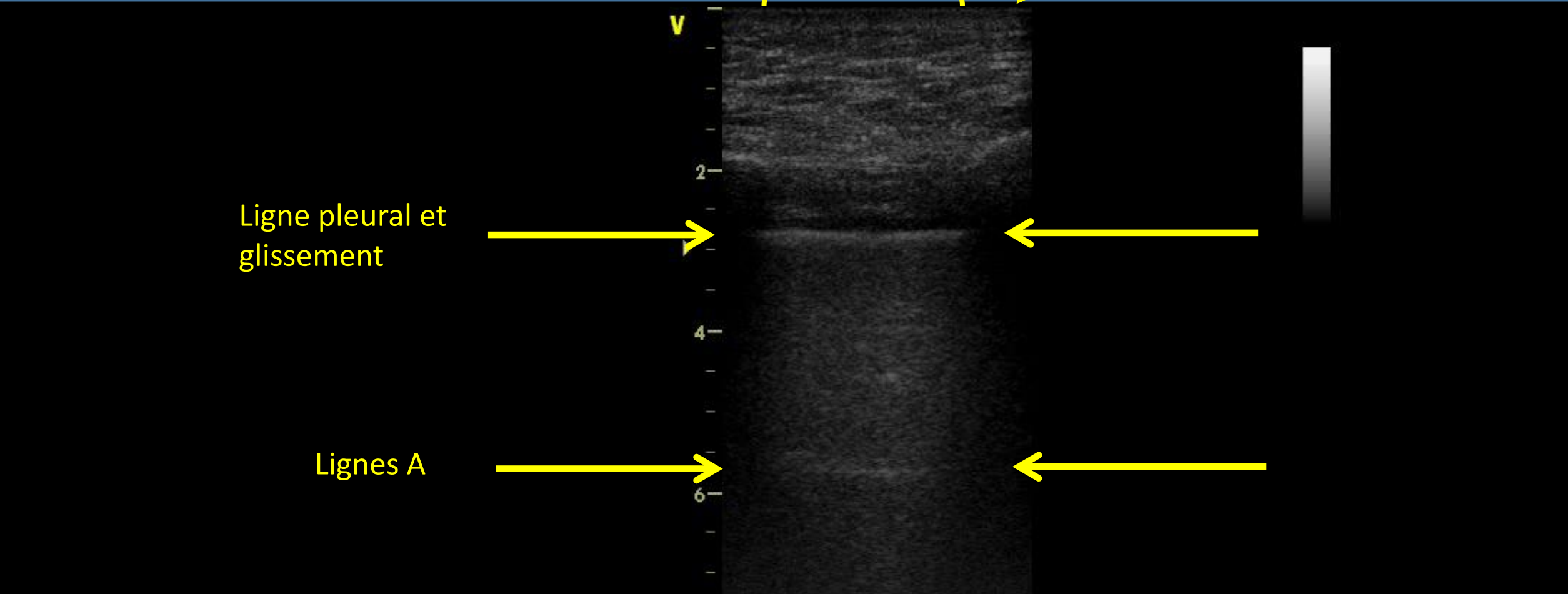
## Real-Time Visualization of Left Lung Consolidation Relief Using Lung Ultrasound

Maxime Nguyen, Salima Benkhadra, Christophe Douquet, and Bélaïd Bouhemad



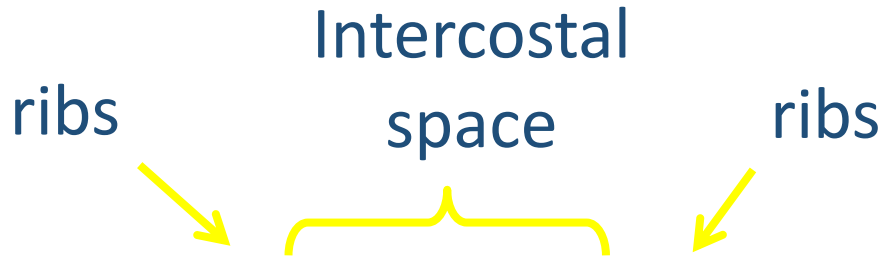
# Glissement pleural et lignes A : aspect normal

côte Espace Intercostal côte

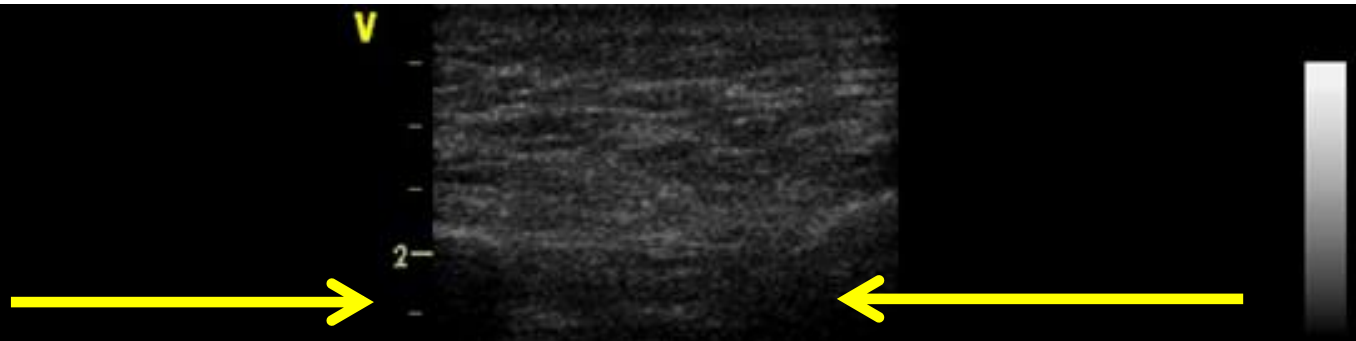


# Pleural effusion: pleural « lines » and anechoic zone

ribs      Intercostal space      ribs

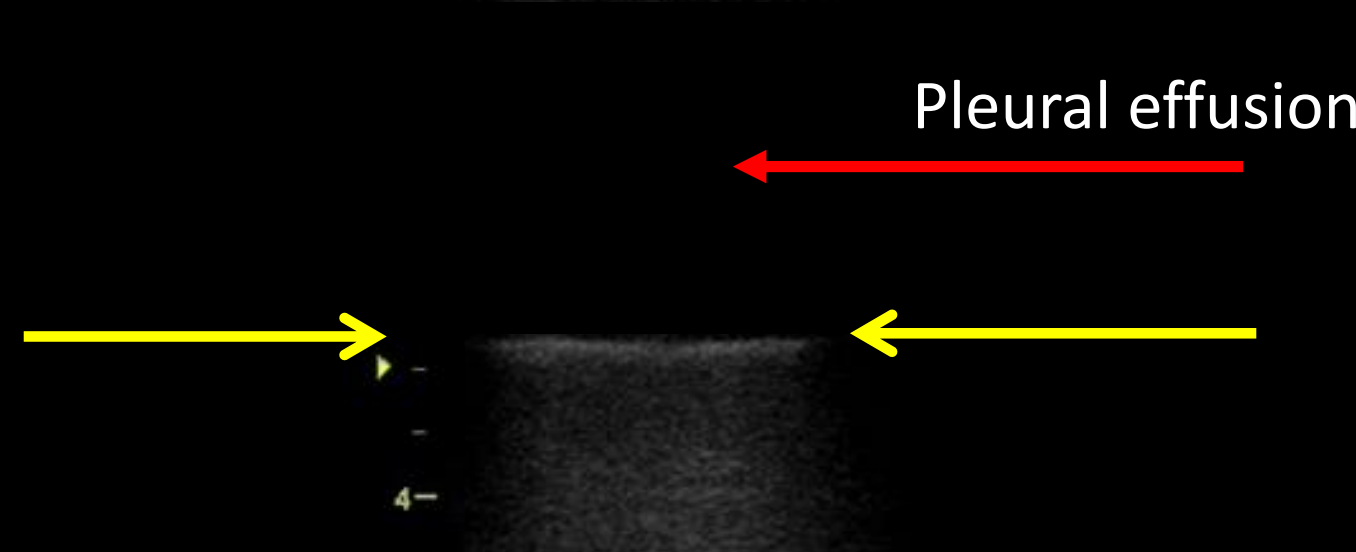
A diagram showing the anatomical layout of an intercostal space. The word "ribs" is written on the left and right. A yellow bracket is drawn below the text "Intercostal space", indicating the area between the ribs.

«parietal pleura»



Pleural effusion

«visceral pleura» on the lung



# Pleural effusion

## US are conducted beyond the pleura

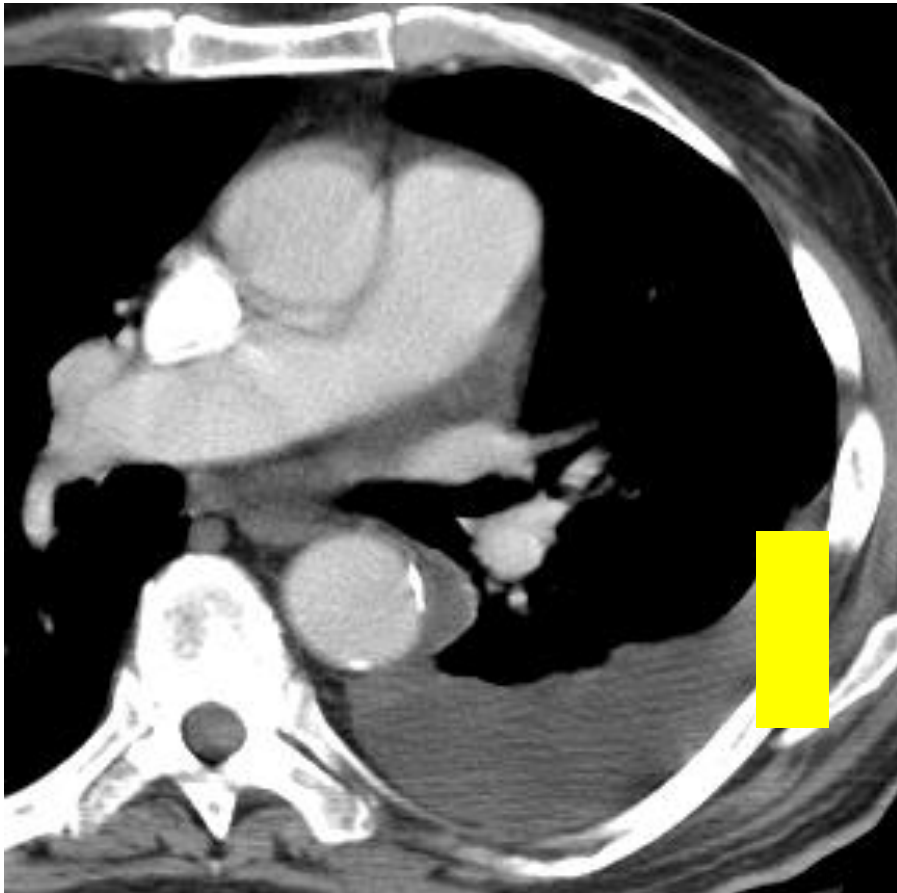
- Absence of Lung sliding
- Direct visualization of pleural effusion
- Sought in dependant zones
- Allow to examine « deep intra-thoracic structures »



# Pleural effusion

**Acoustic window**, visualisation  
deep intra-thoracic structures

- Hypoechoic (**black**)
- Homogeneous



# Pleural effusion

**Acoustic window**, visualization deep intra-thoracic structures

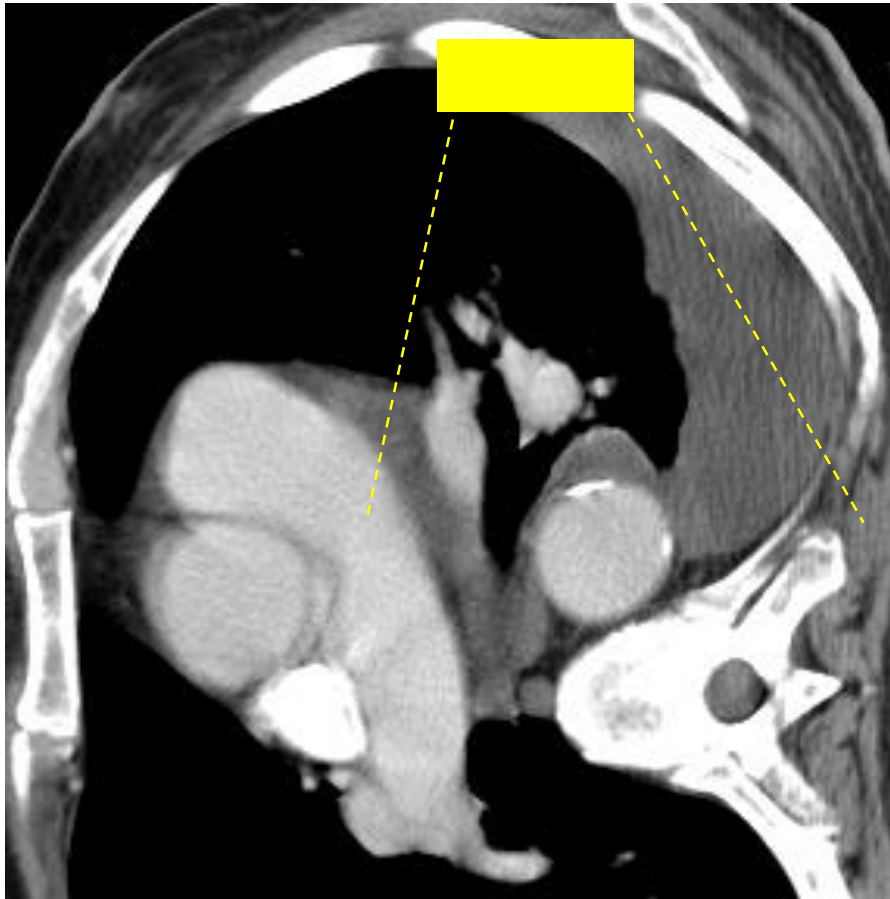
- Hypoechoic (**black**)
- Homogeneous



# Pleural effusion

**Acoustic window**, visualisation  
deep intra-thoracic structures

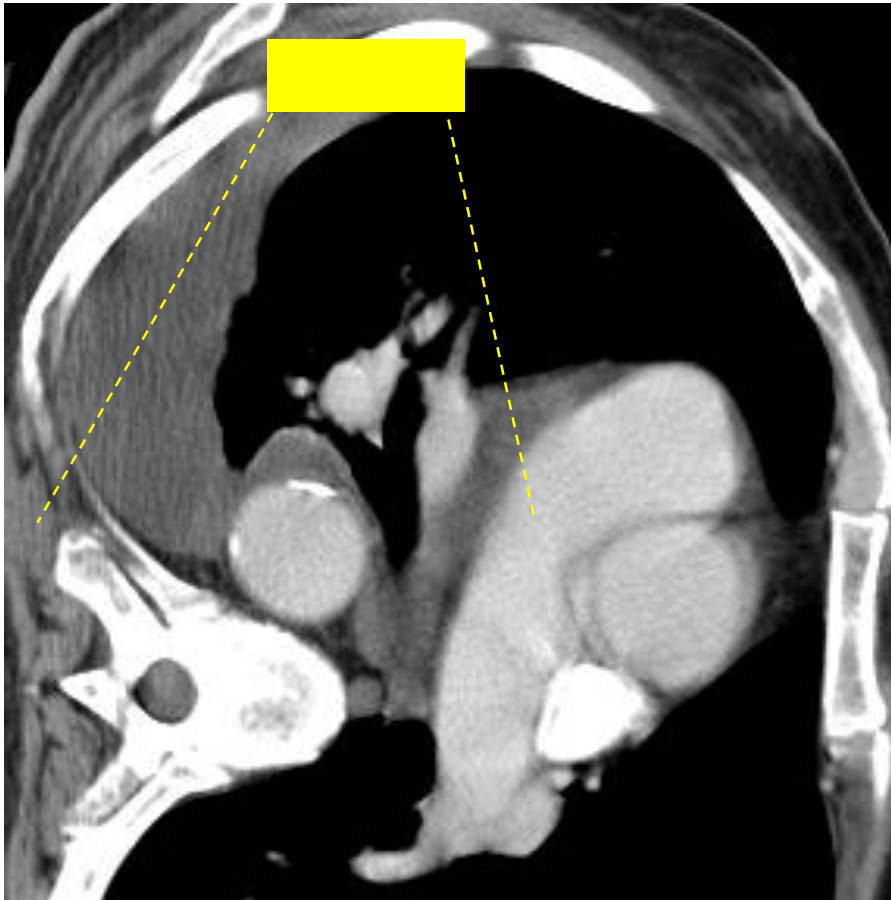
- Hypoechoic (**black**)
- Homogeneous



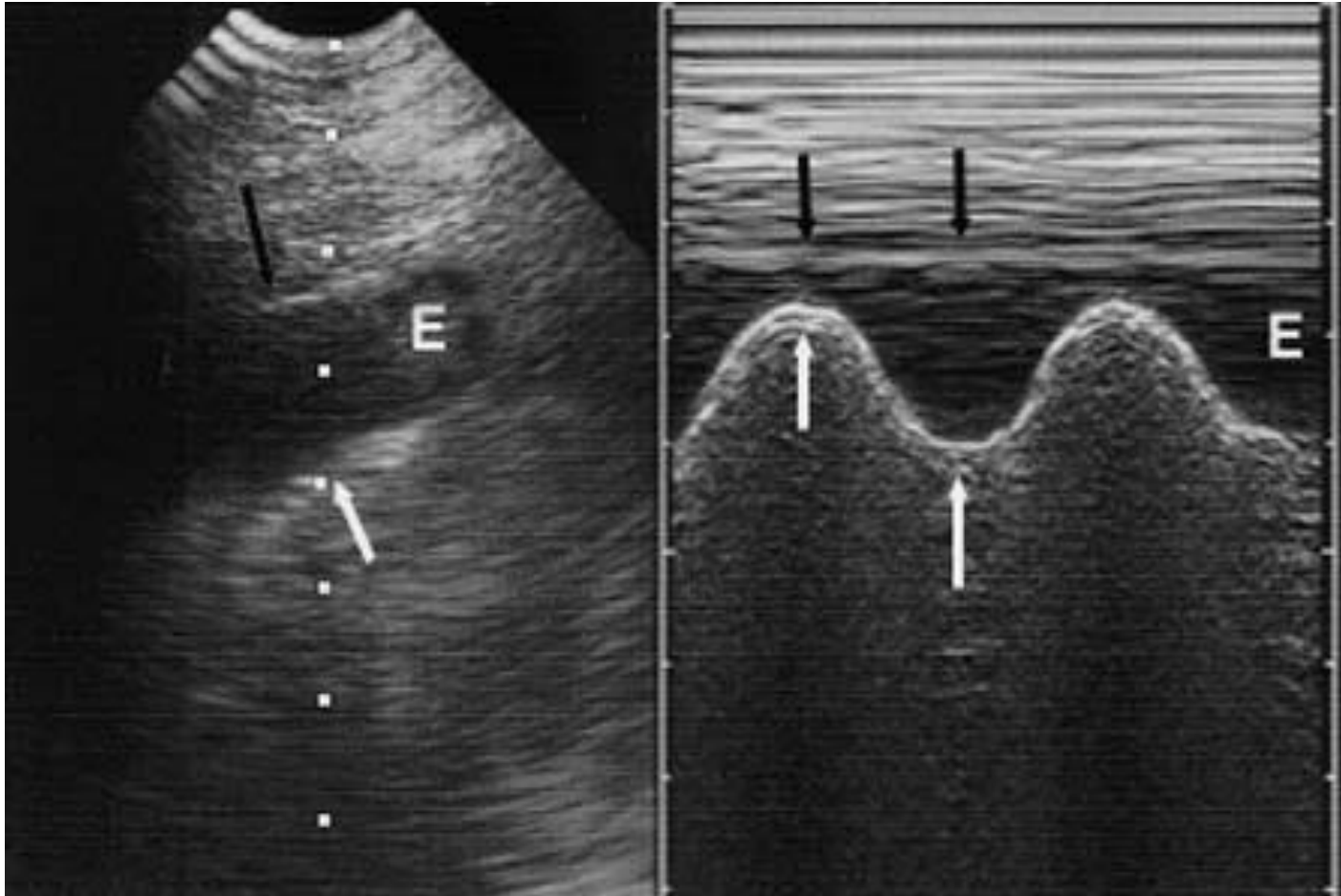
# Pleural effusion

**Acoustic window**, visualization deep intra-thoracic structures

- Hypoechoic (**black**)
- Homogeneous



# Pleural effusion in TM: Sinusoid signe

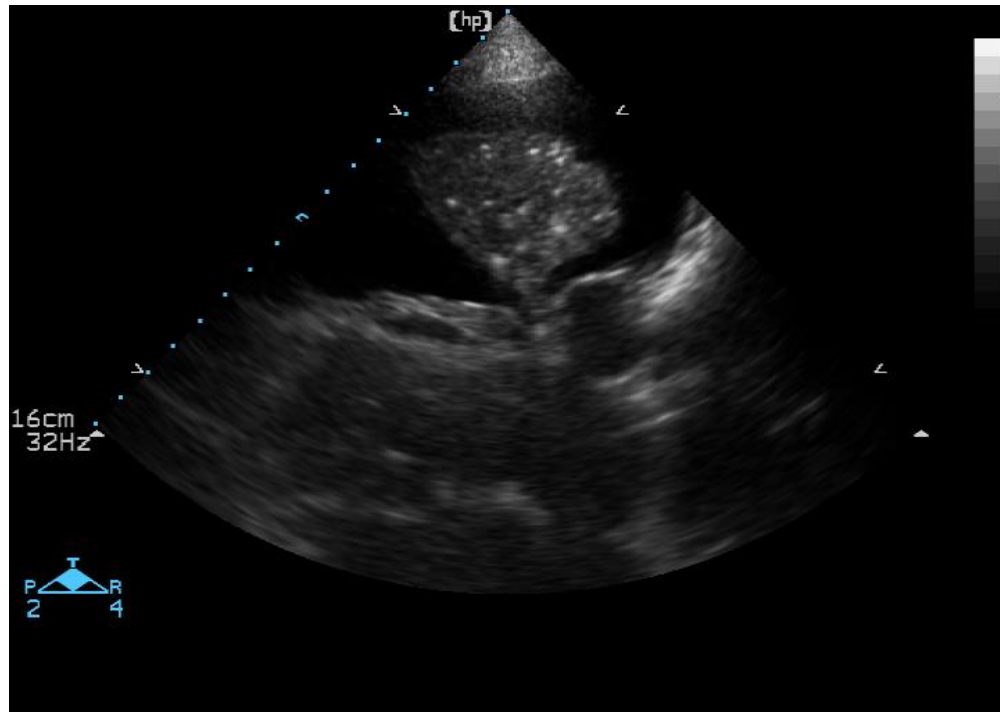


Sinusoidal inspiratory movement of the visceral pleura from depth to periphery



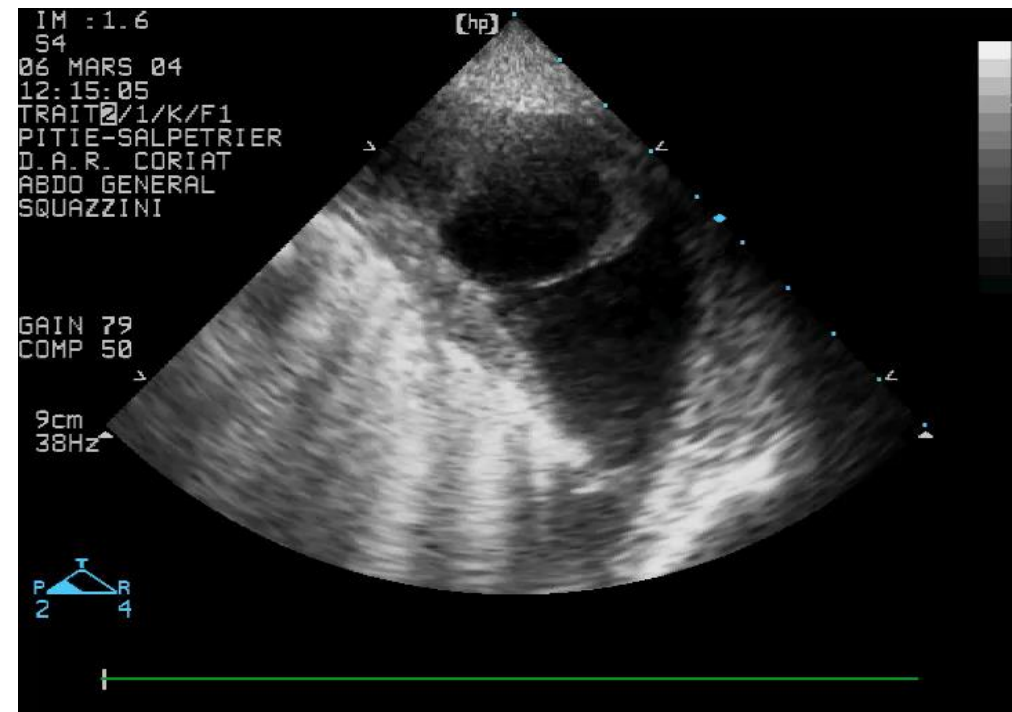
# Pleural effusion: Exsudate or Transudate ?

## Transudate



- Anechoic (**black**)
- Homogeneous

## Exsudate



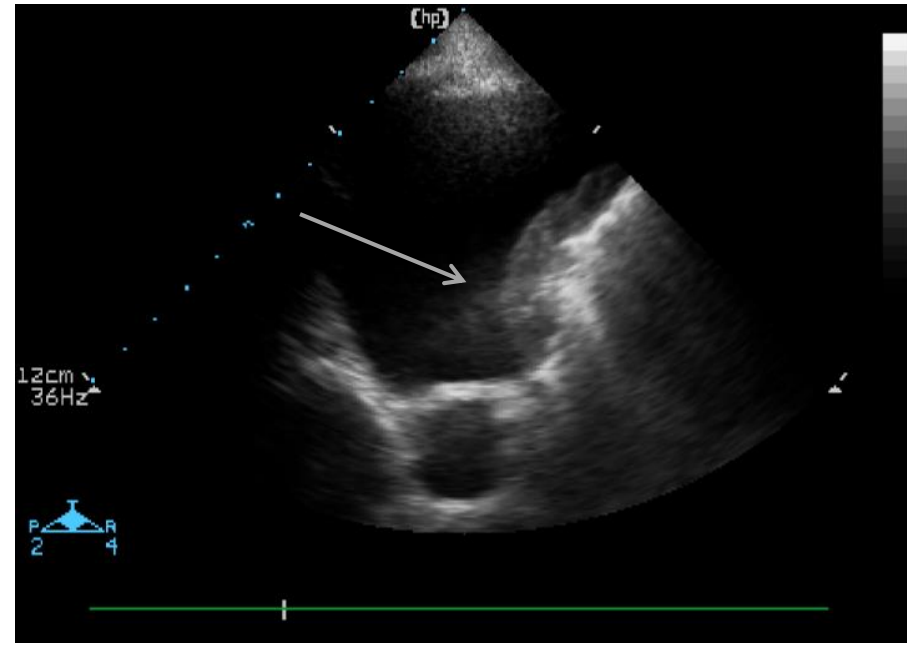
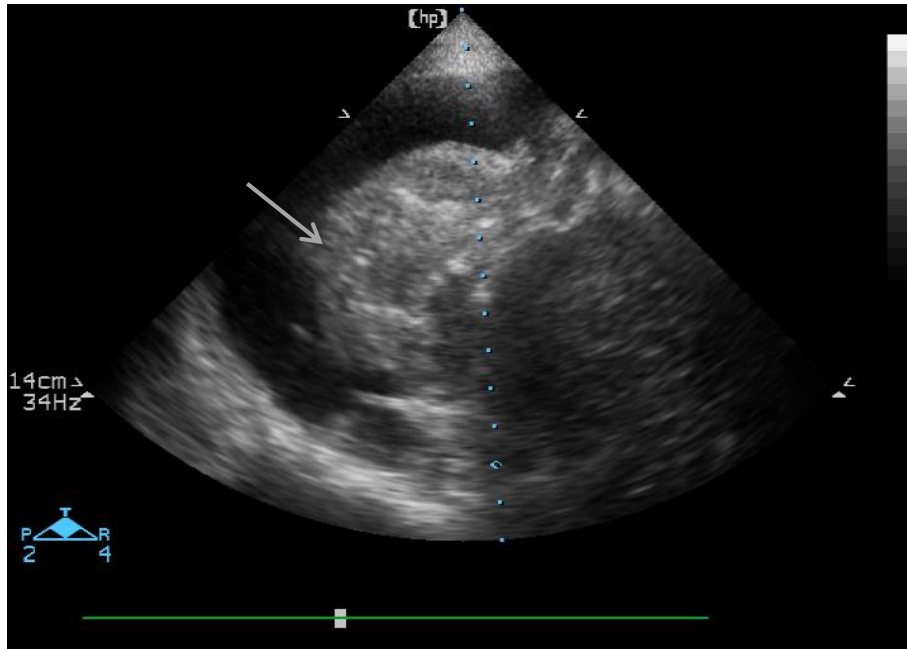
- echoic (**White points**)
- Inhomogeneous
- Loculated



# How to quantify Pleural effusion easily and quickly?

## Measurement of maximal interpleural distance

- On a patient strictly lying supine
- **Max. Interpleural distance > 5 cm**
- **Significant pleural effusion > 500 – 1000 ml**



# Epanchement pleural

- **Diagnostic de l'épanchement O/N**

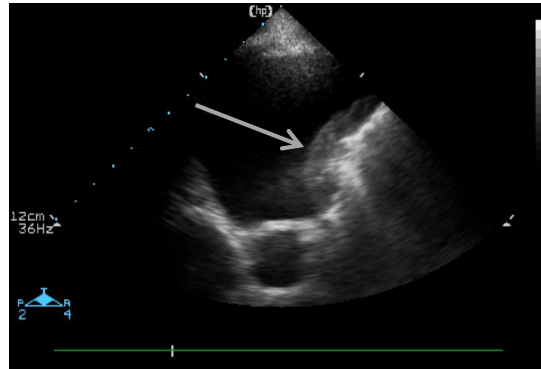
- Nature Exsudat/transudat  
Homogène/ hétérogène

- **Aide à la ponction**

- **Quantification > 500 ml**
  - Distance interpleurale

- **Drainage**

- Guide à la ponction
- Localisation du poumon
- Brides/ cloisonnement





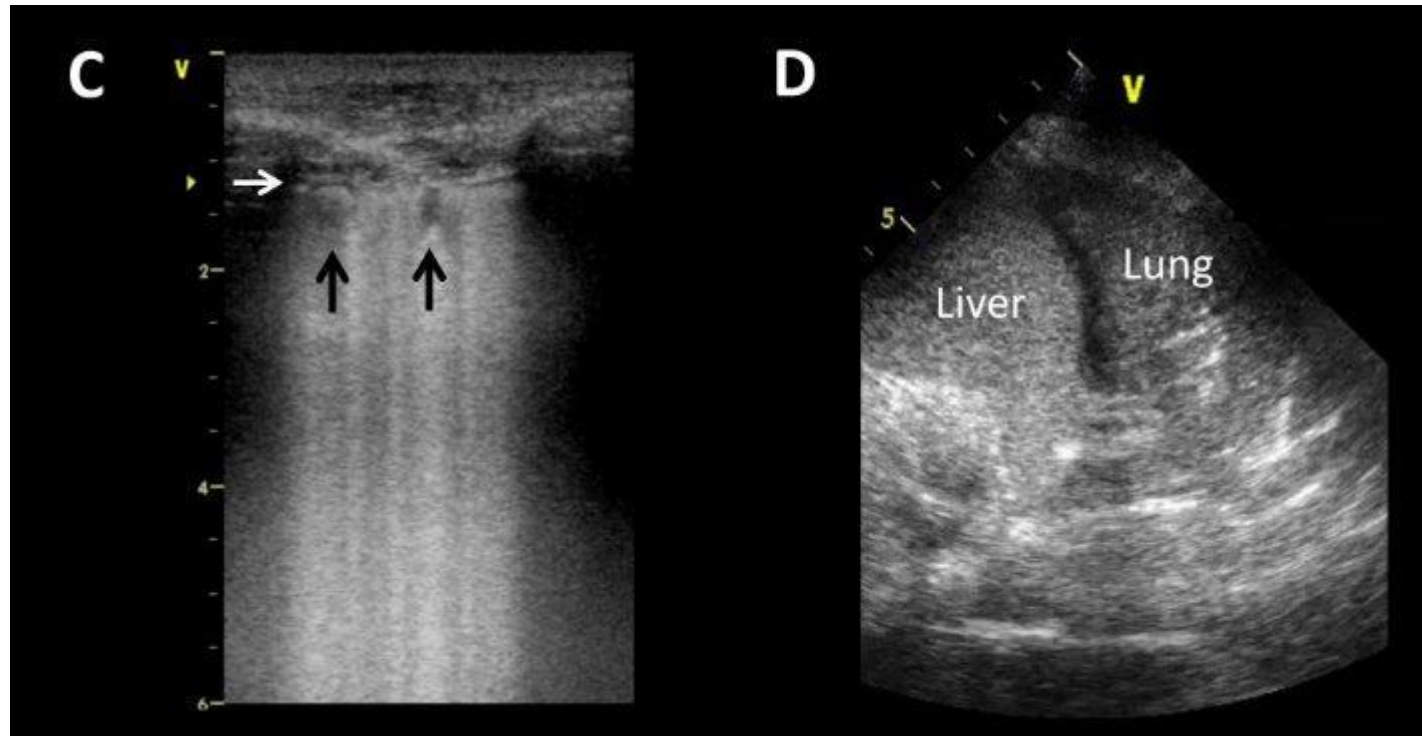
**Comment utiliser tous ces signes ?**

**REVIEW**

# Clinical review: Lung imaging in acute respiratory distress syndrome patients - an update

Davide Chiumello<sup>1\*</sup>, Sara Froio<sup>1</sup>, Belaïd Bouhemad<sup>2</sup>, Luigi Camporota<sup>3</sup> and Silvia Coppola<sup>1</sup>

## Consolidations sous pleurale et lobaire



# Clinical review: Lung imaging in acute respiratory distress syndrome patients - an update

Davide Chiumello<sup>1\*</sup>, Sara Froio<sup>1</sup>, Belaid Bouhemad<sup>2</sup>, Luigi Camporota<sup>3</sup> and Silvia Coppola<sup>1</sup>

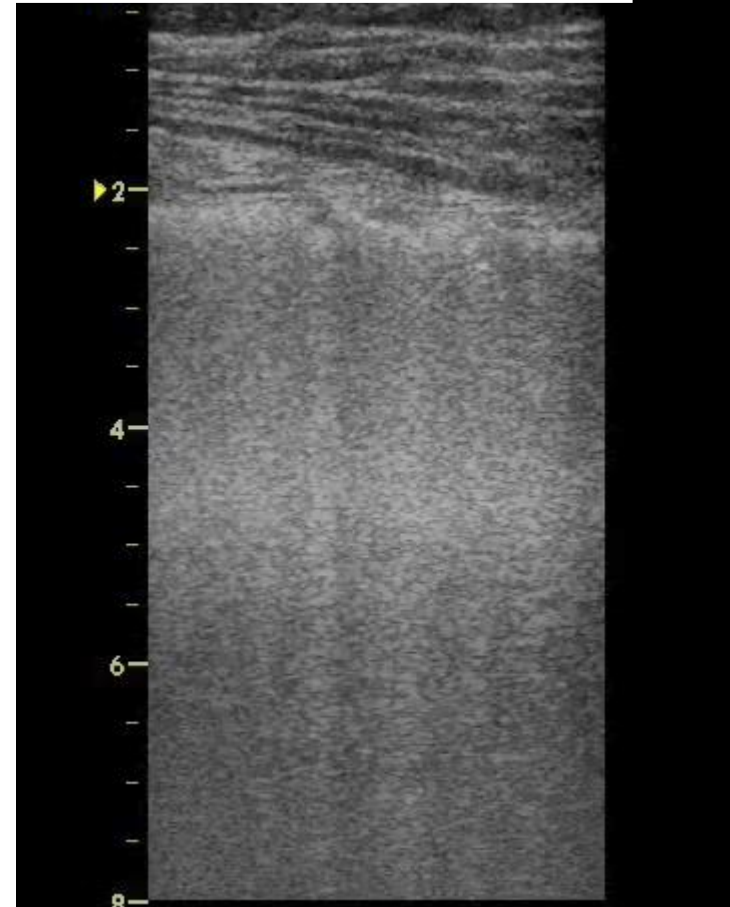
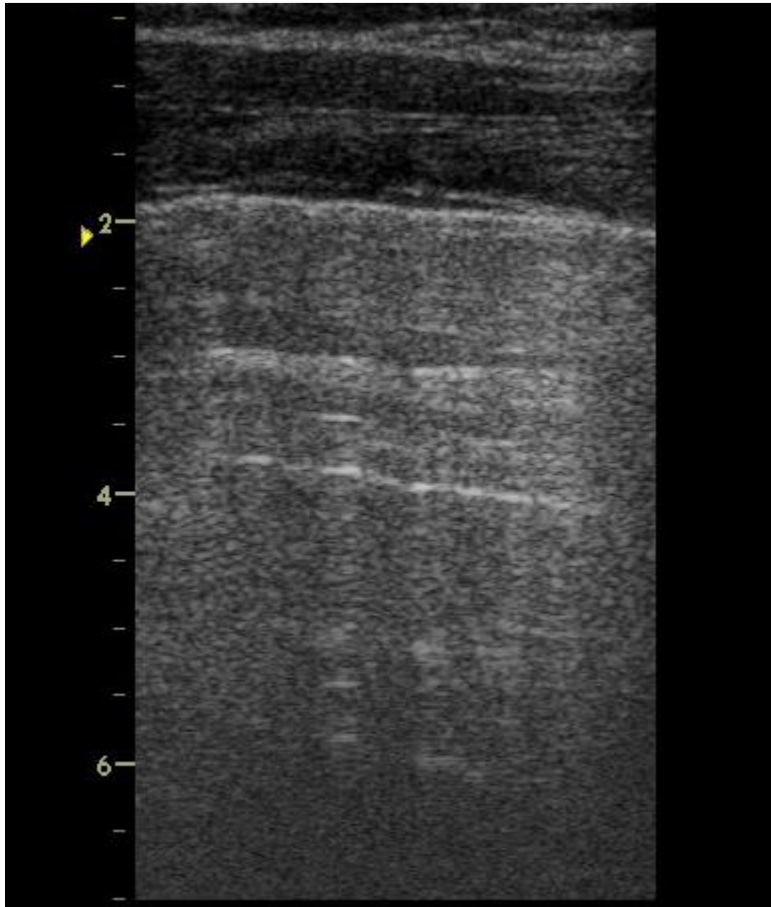
- Lignes-B coalescentes
- Consolidation juxtapleurale
- Zones normales





# Clinical review: Lung imaging in acute respiratory distress syndrome patients - an update

Davide Chiumello<sup>1\*</sup>, Sara Froio<sup>1</sup>, Belaïd Bouhemad<sup>2</sup>, Luigi Camporota<sup>3</sup> and Silvia Coppola<sup>1</sup>



Abolition du glissement et «Lung Pulse»

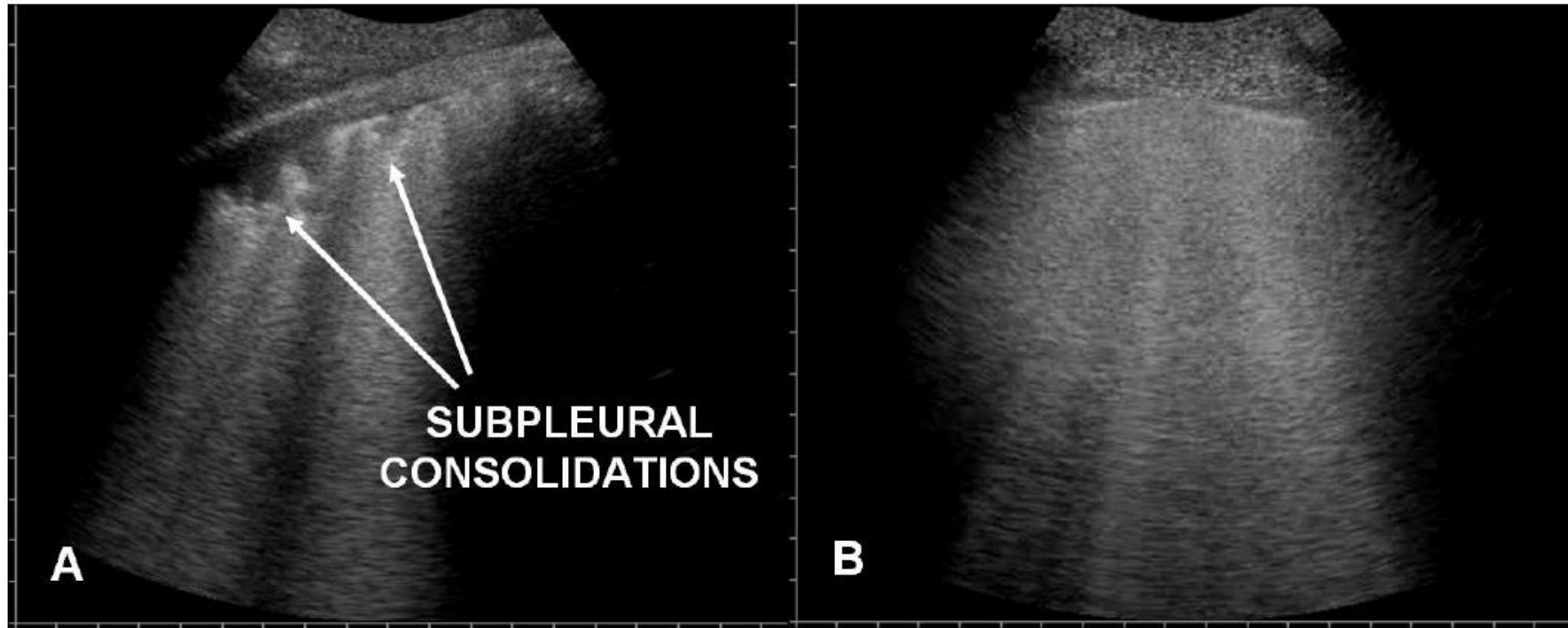


Research

**Open Access**

## **Chest sonography: a useful tool to differentiate acute cardiogenic pulmonary edema from acute respiratory distress syndrome**

Roberto Copetti\*<sup>1</sup>, Gino Soldati<sup>2</sup> and Paolo Copetti<sup>1</sup>



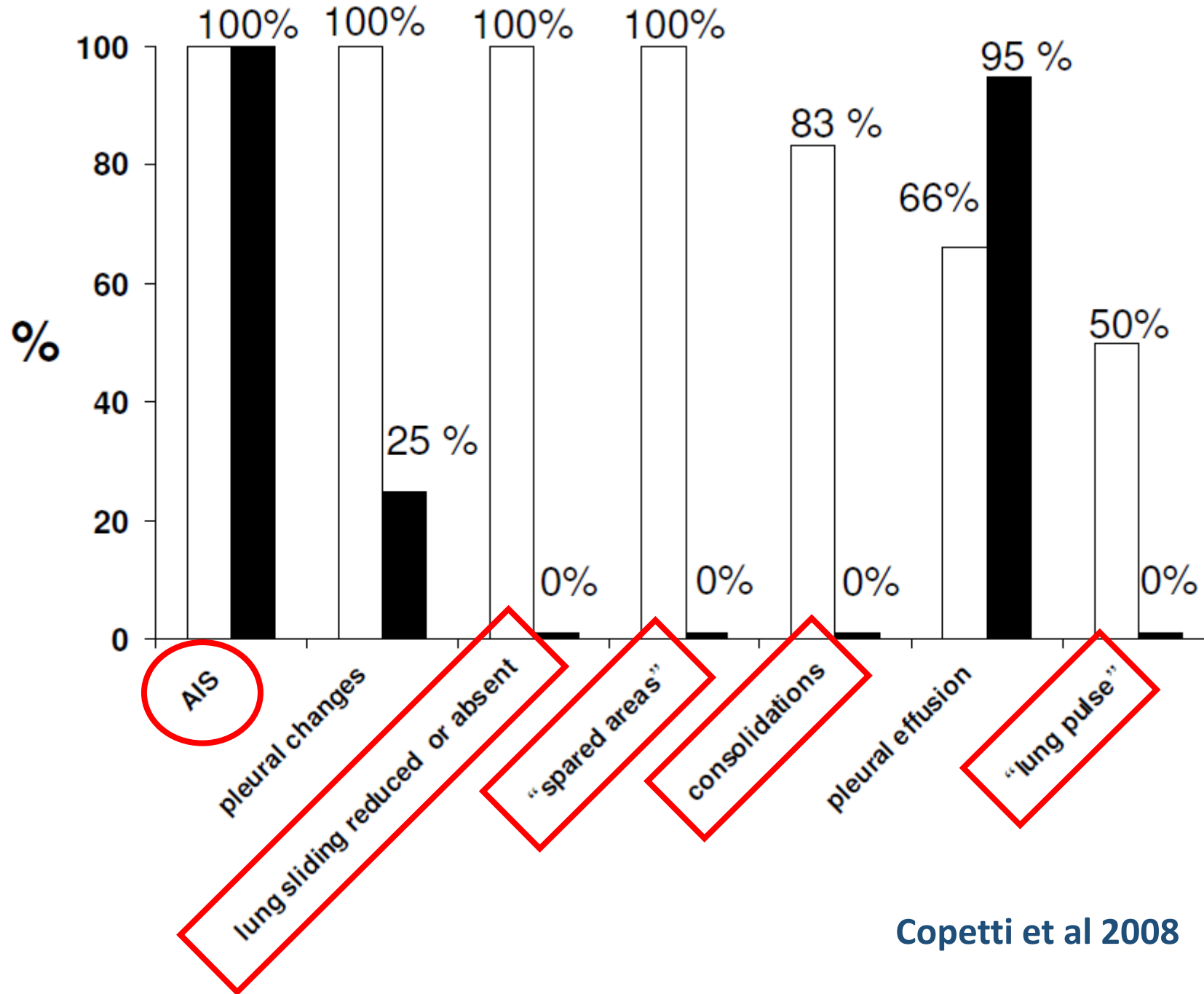
**A**

**SUBPLEURAL  
CONSOLIDATIONS**

**B**

**ARDS**

**ACPE**

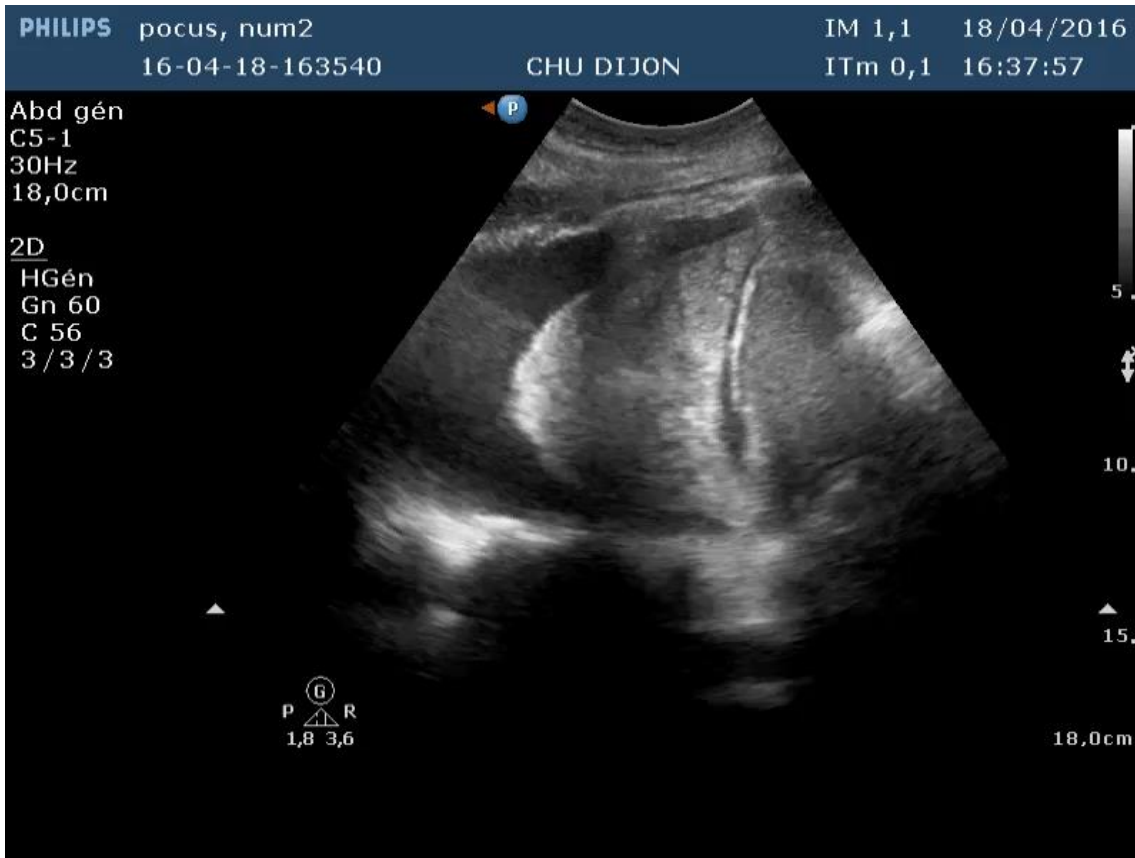


Copetti et al 2008

# Pleural effusion: a daily case

41 year old woman with is admitted from ED with septic shock and hypoxemia

Day 1

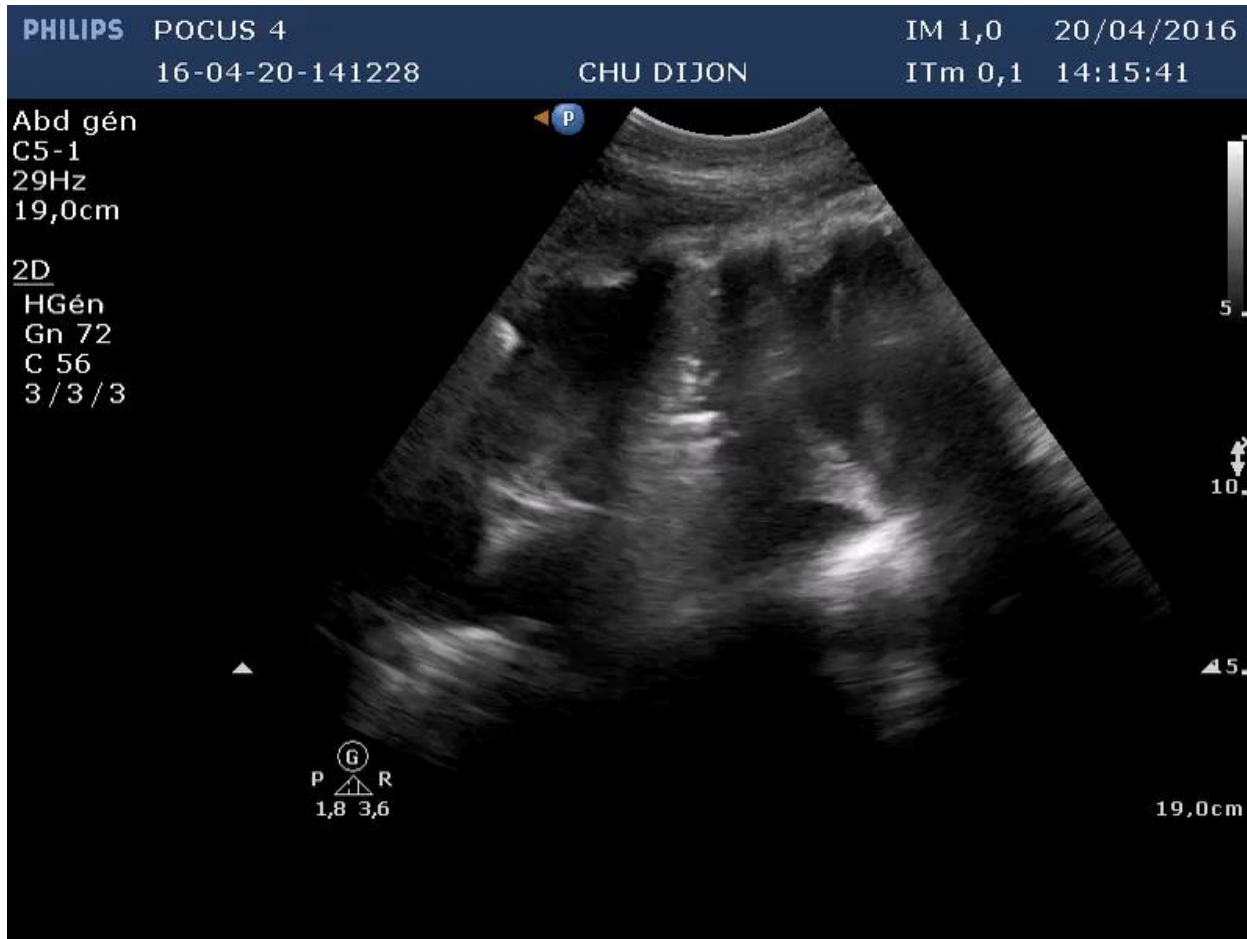


Day 2

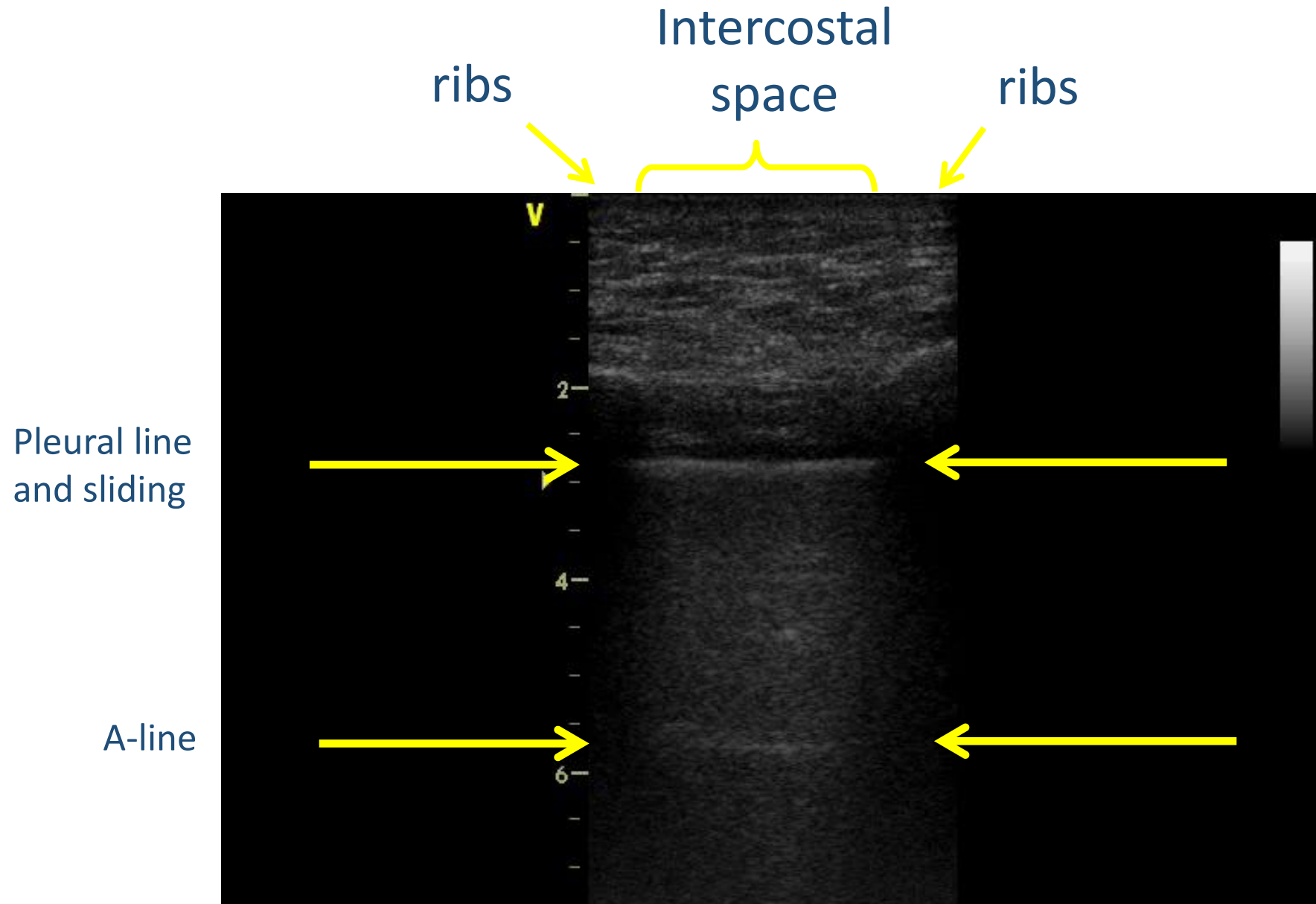


# Pleural effusion: a daily case

At **day 2**, after volemic expansion (+ 10 Kg) and antibiotics



# Pleural sliding and A-lines: US findings for normal lung



# Pleural sliding and A-lines: US findings for normal lung



-Pleural line+ pleural sliding

A-lines :Horizontal lines



# Pneumothorax

## Echo signs of Pneumothorax

- Absence of Lung sliding
- Presence of B-lines eliminates pneumothorax
- Lung point is the « sign »

# Absence of Lung sliding (2D)



← Pleural line

← A-lines

← A-lines

# Lung sliding (TM) “seashore” or “stratosphere” pattern

Pleural line →

presence of lung sliding  
appears as  
a **linear and grainy image**  
-> **“seashore” pattern**



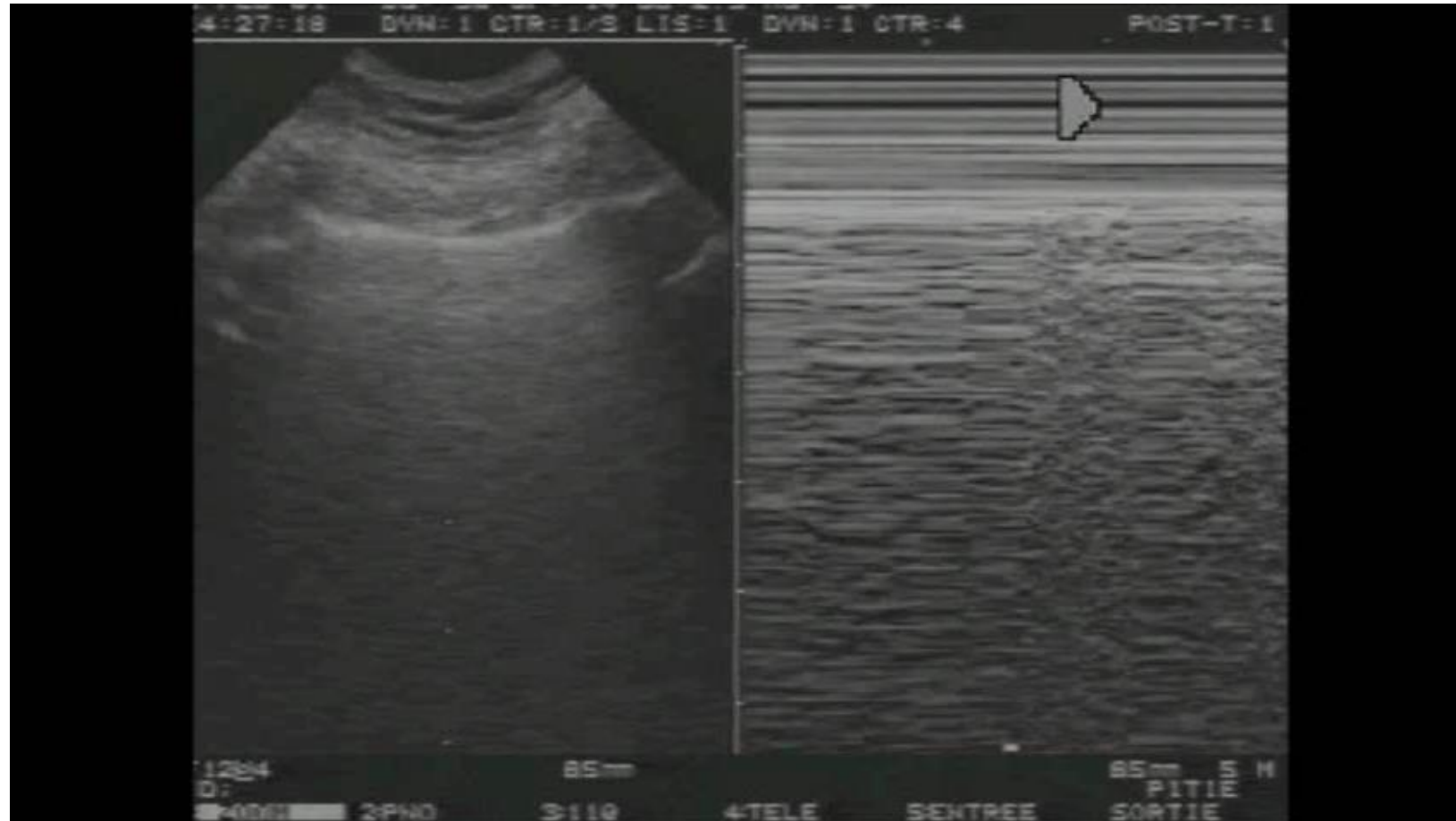
# Lung sliding (TM) “seashore” or “stratosphere” pattern

Pleural line →

absence of lung sliding and  
presence of static A-lines  
appears as  
a **completely linear** pattern ->  
**“stratosphere” pattern**



# Lung sliding (TM) “seashore” or “stratosphere” pattern

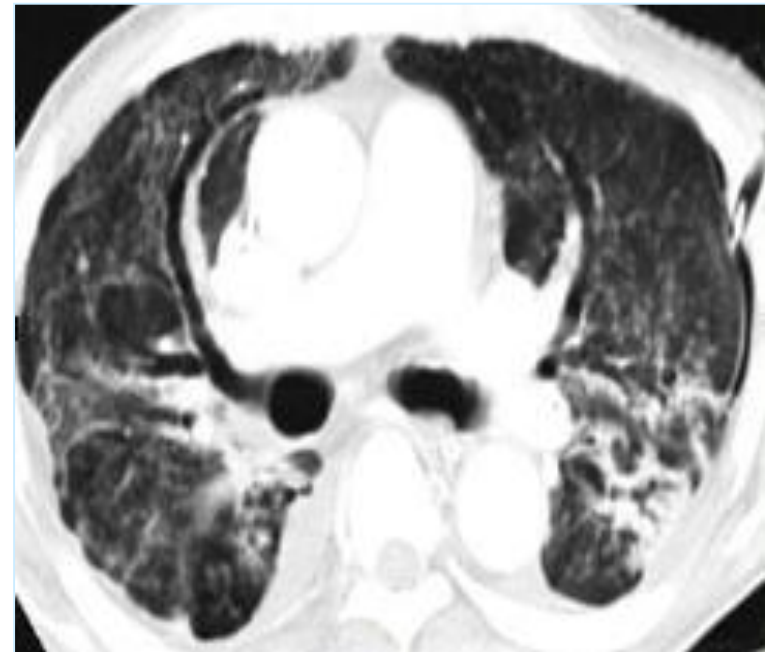


# Reduced sliding can be due to different pathologies

- -Presence of B-lines eliminates pneumothorax



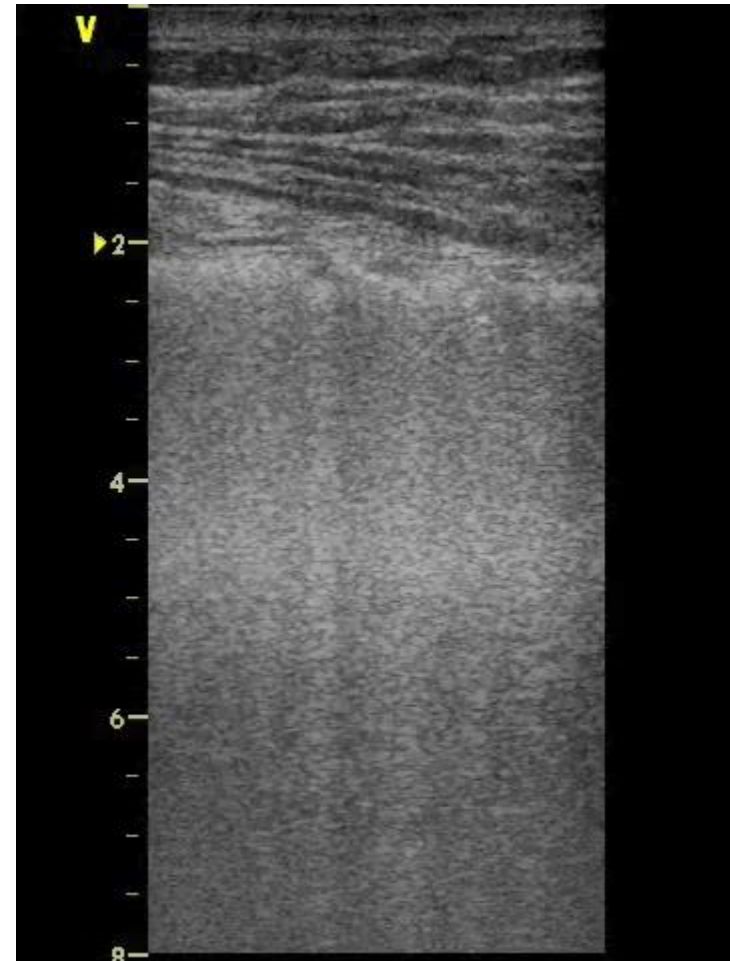
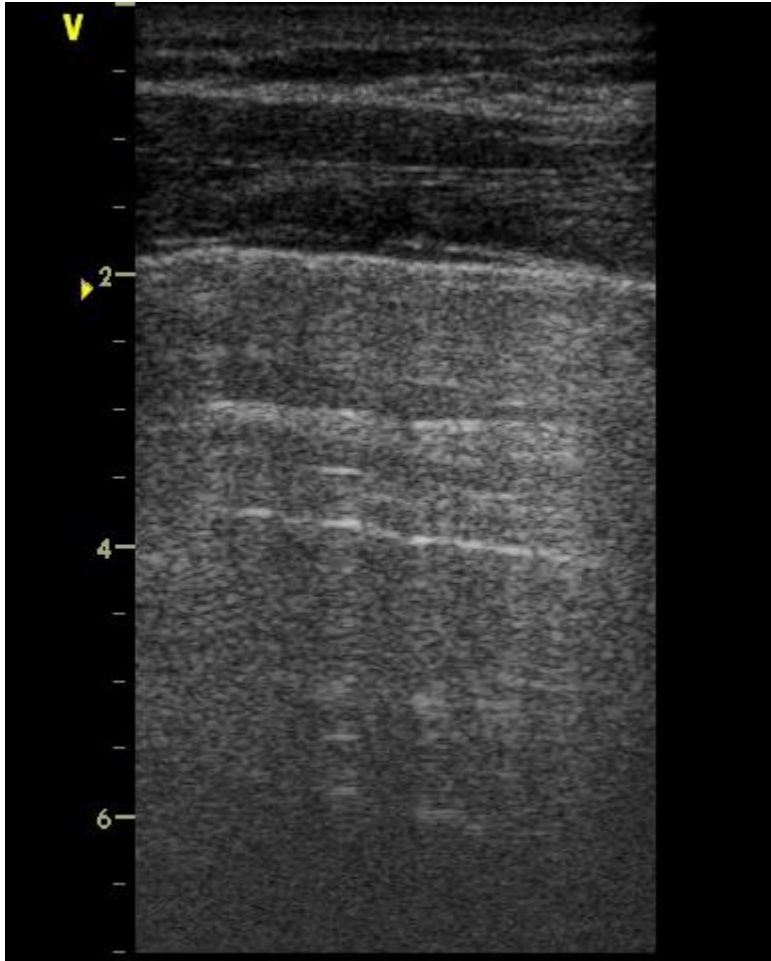
emphysematous bullae



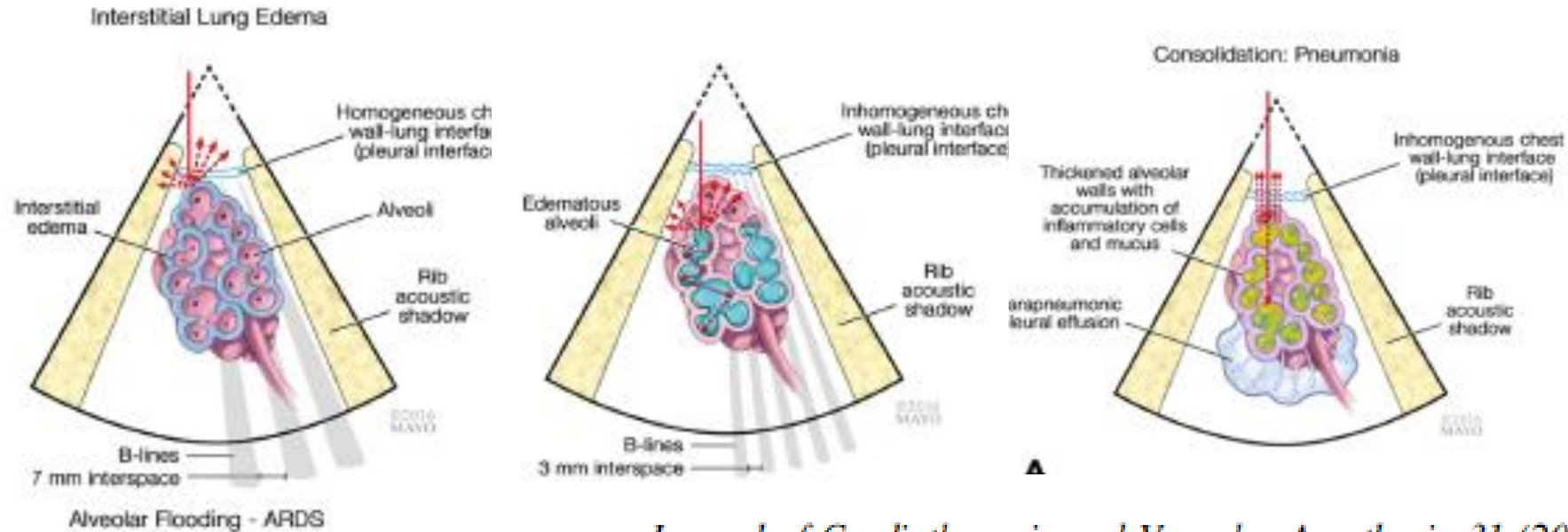


# Reduced sliding can be due to different pathologies

Abolished pleural sliding and «Lung Pulse» in ARDS patients



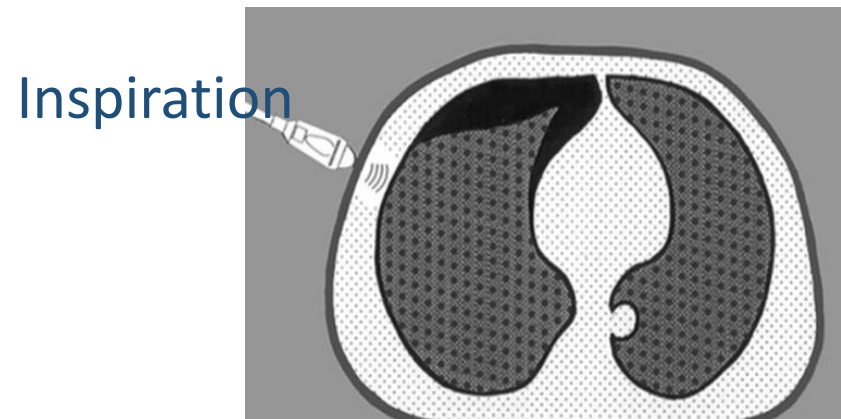
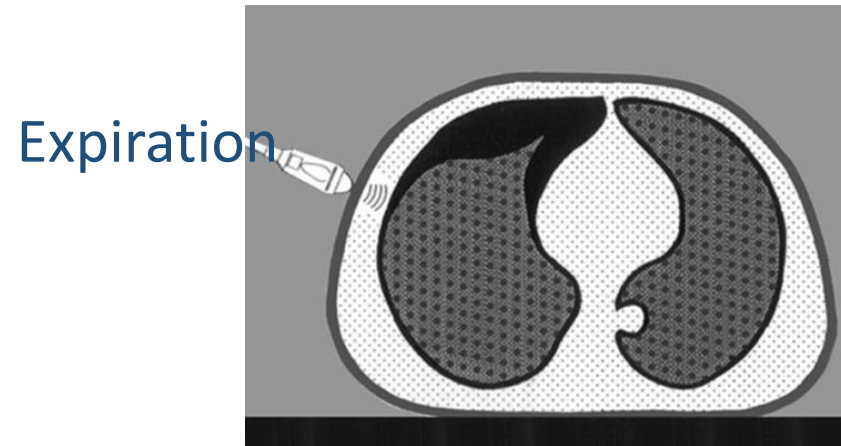
# To summarize : Sliding and B-lines



*Journal of Cardiothoracic and Vascular Anesthesia 31 (2017) 610–625*

-Lung sliding and B-lines or consolidation derived from the visceral pleura allow for easily ruling out pneumothorax (negative predictive value 100%)

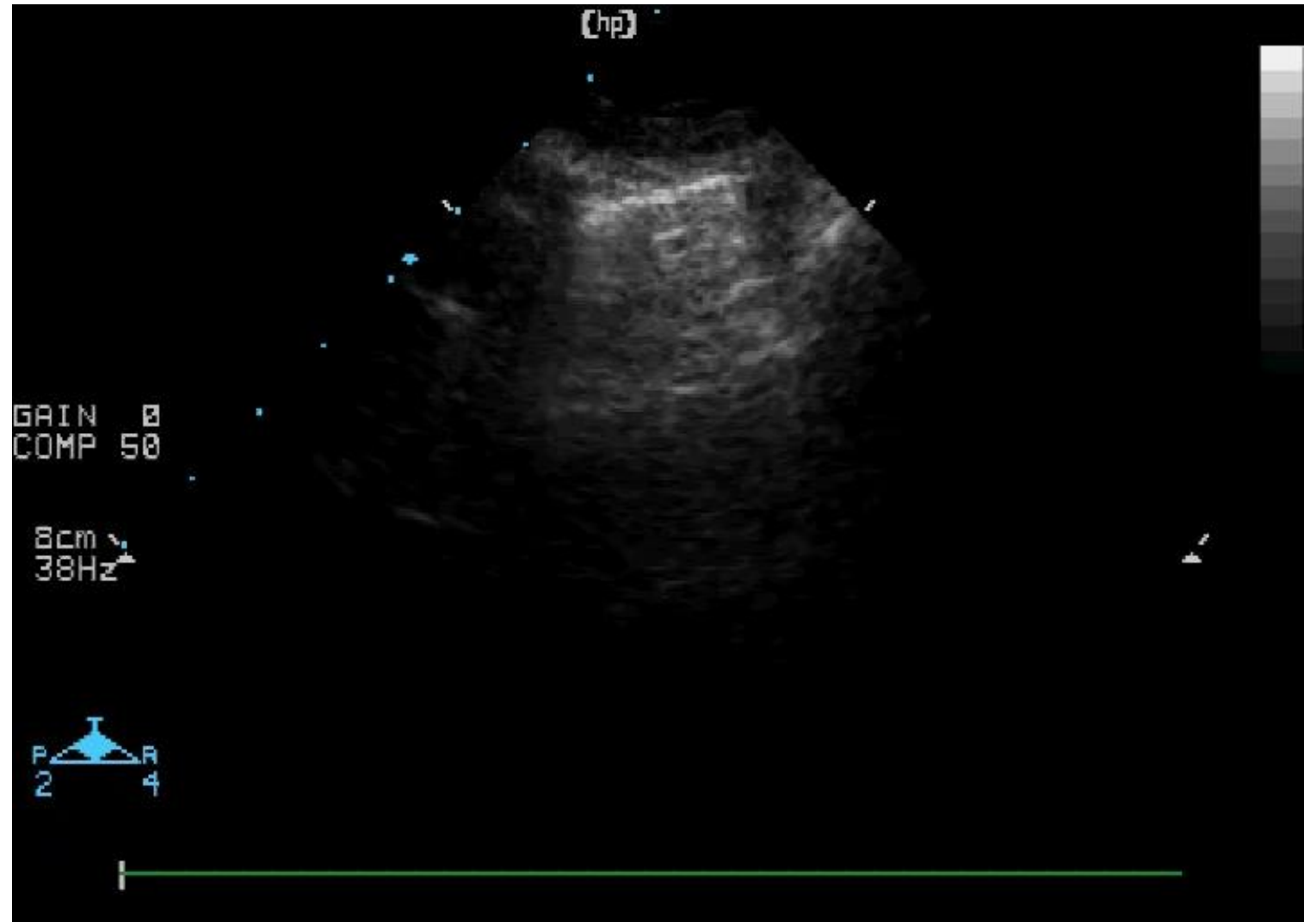
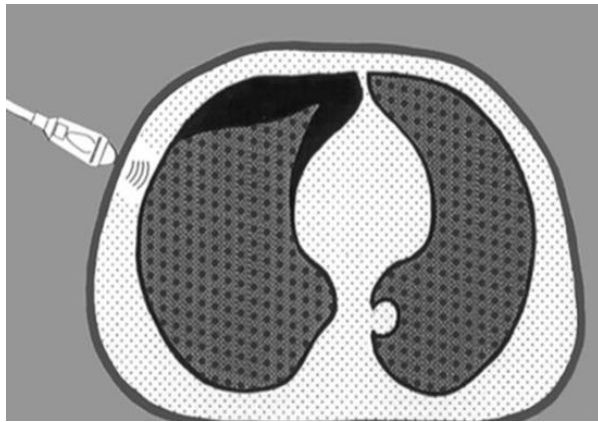
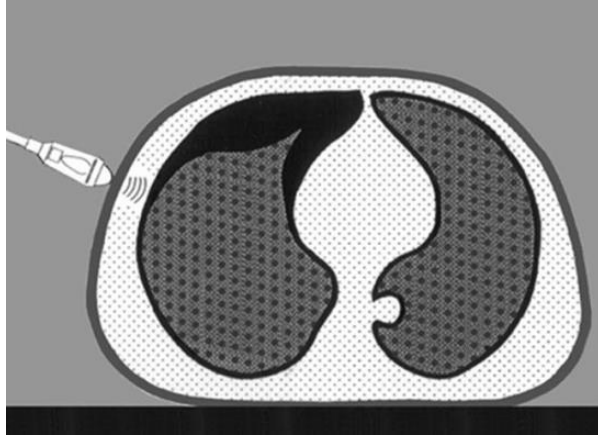
# How to look for the lung point



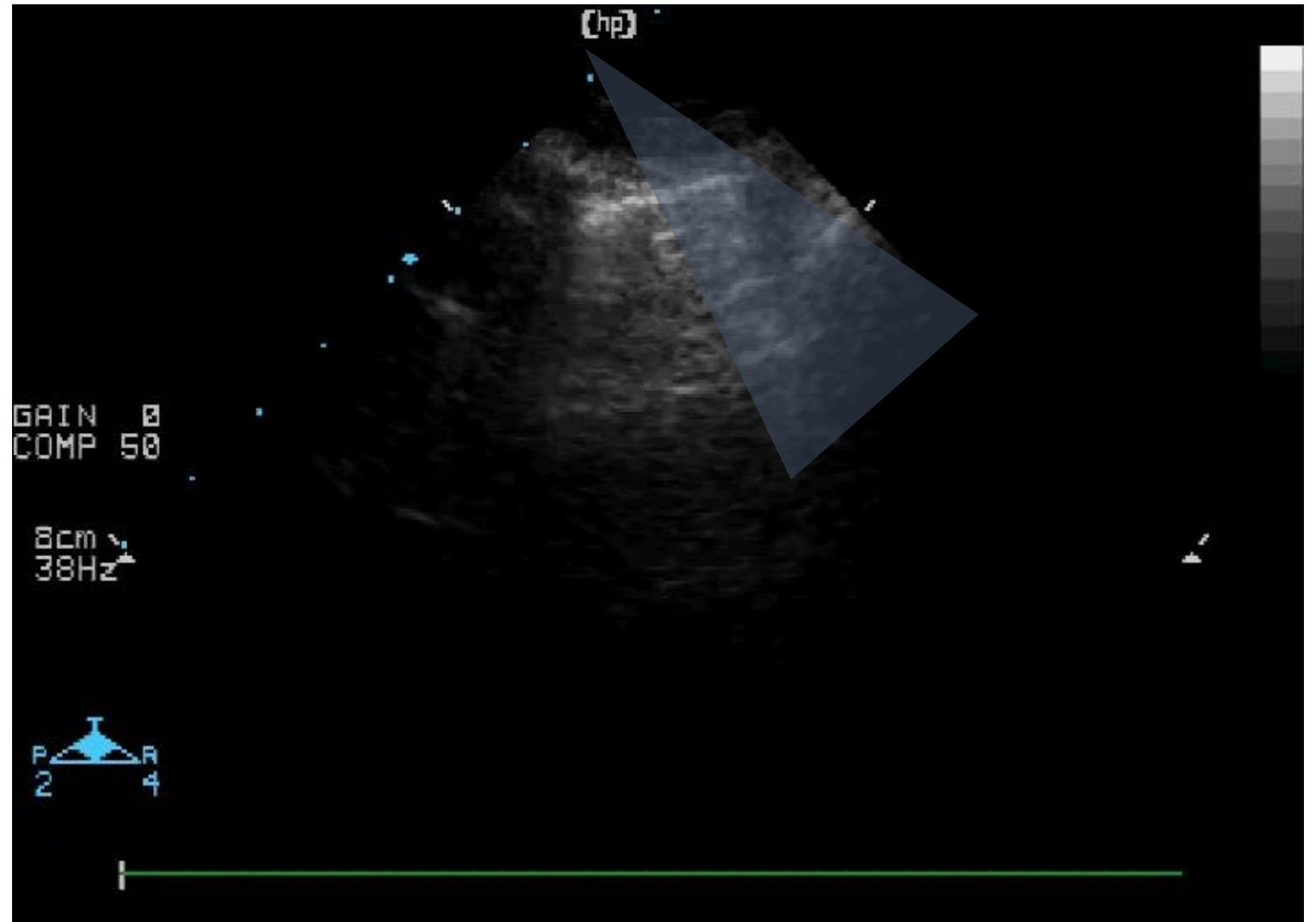
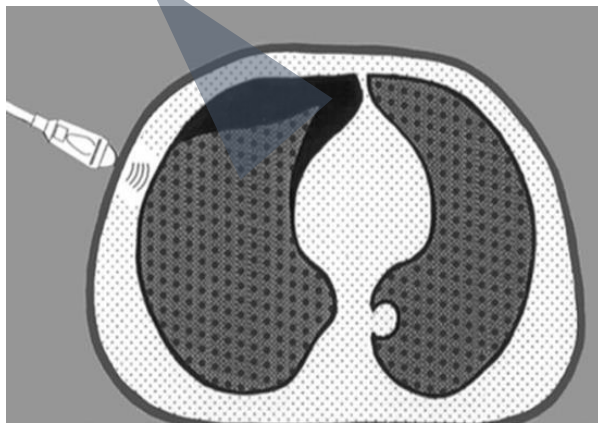
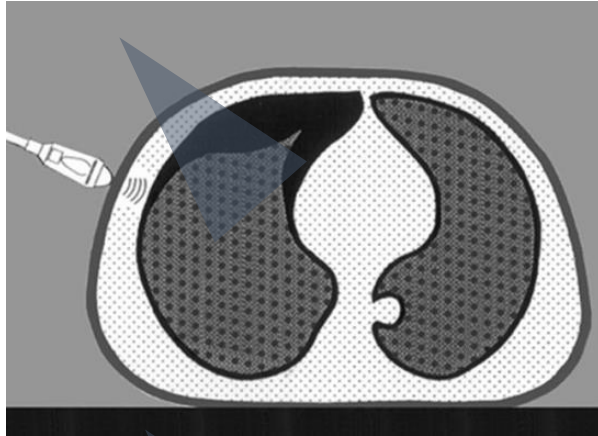
In a supine patient, air collections move to nondependent regions, the echo-performer will start LUS examination from anterior fields.

**D Lichtenstein Critical Care Medicine 33 : 1231 , 2006**

# How to look for the lung point

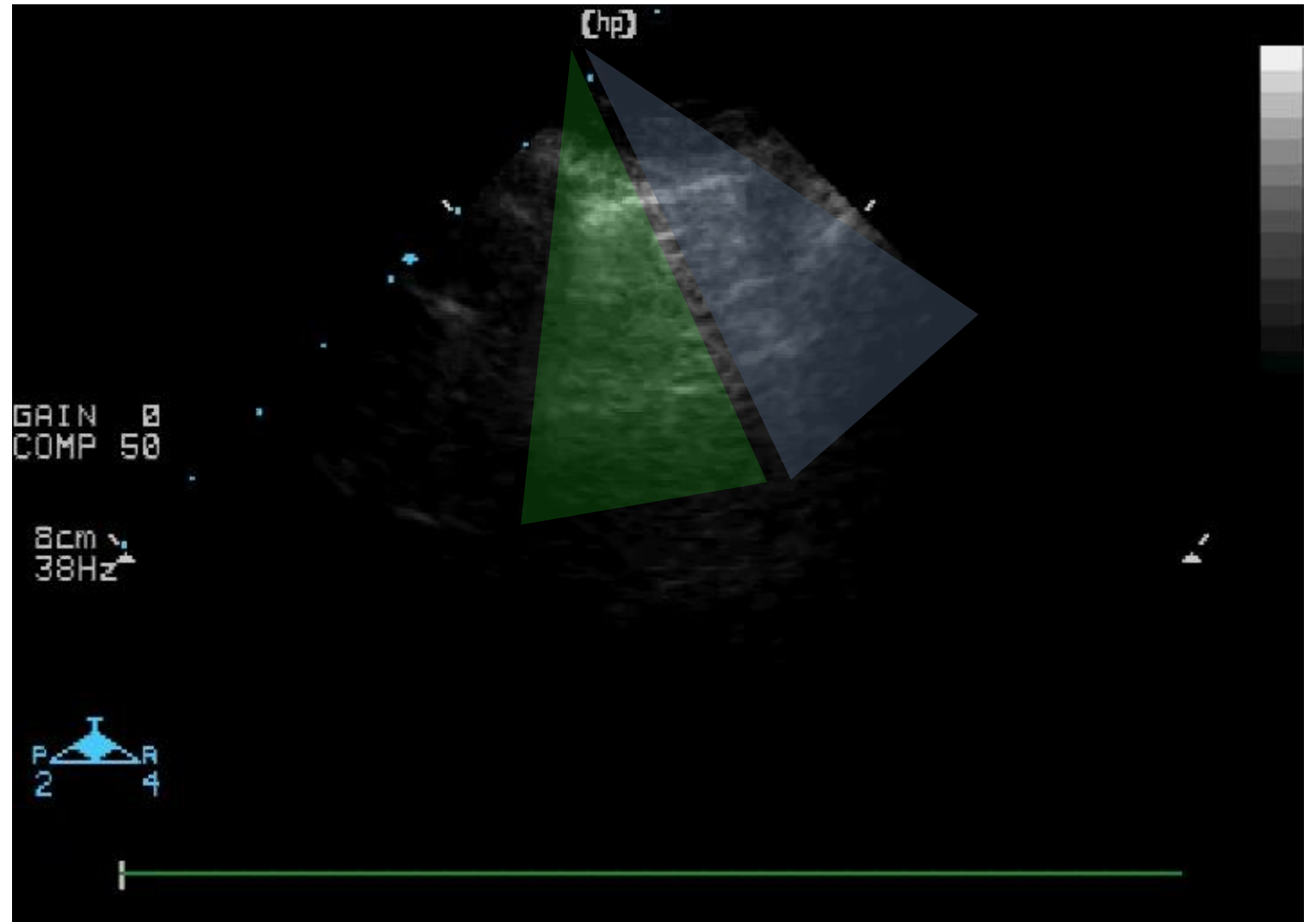
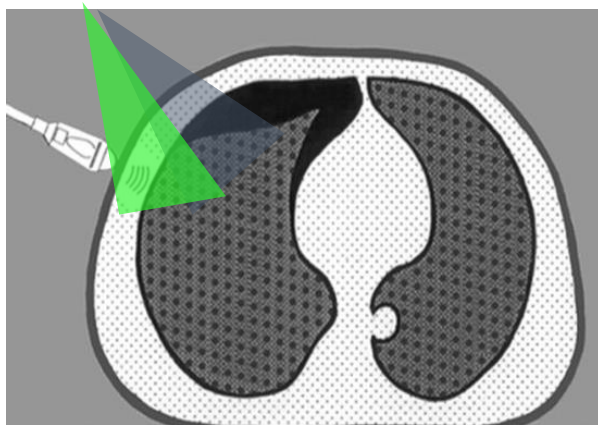
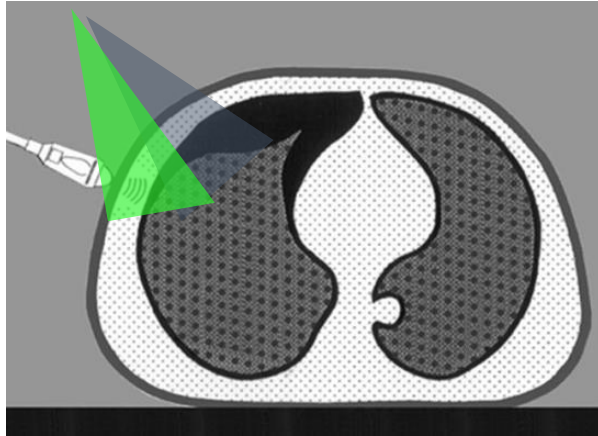


# How to look for the lung point



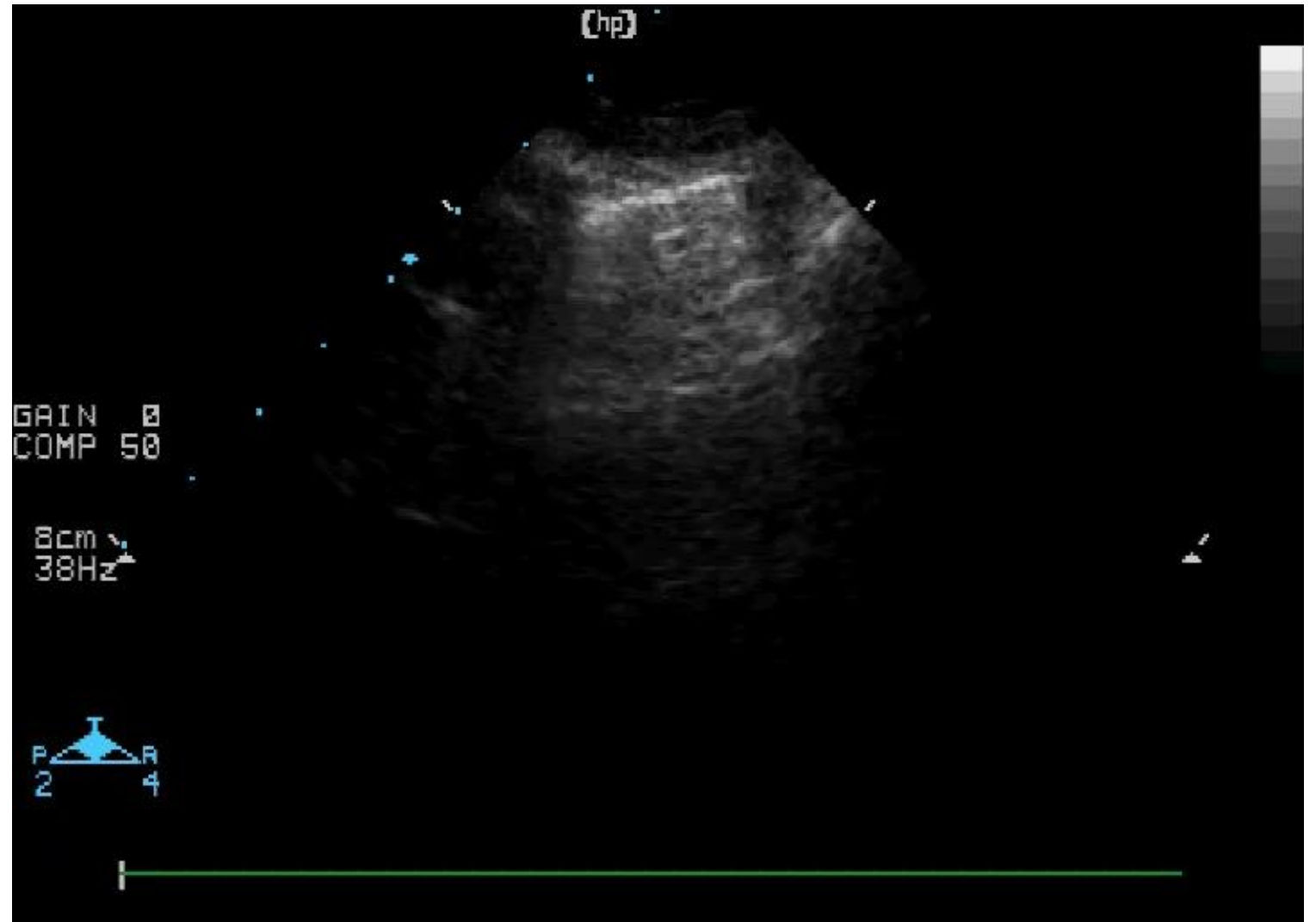
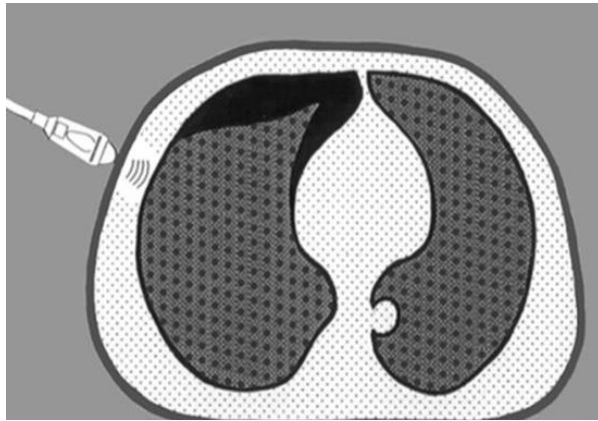
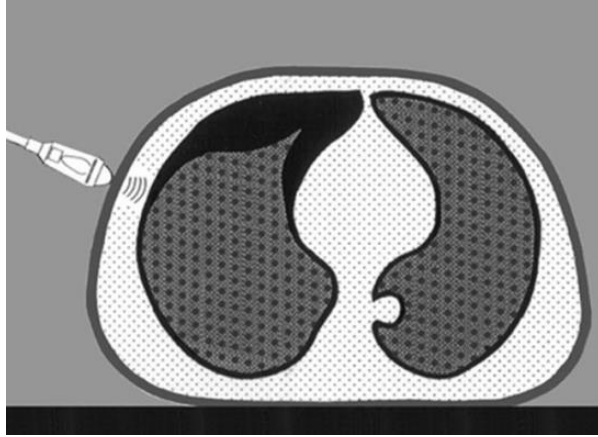


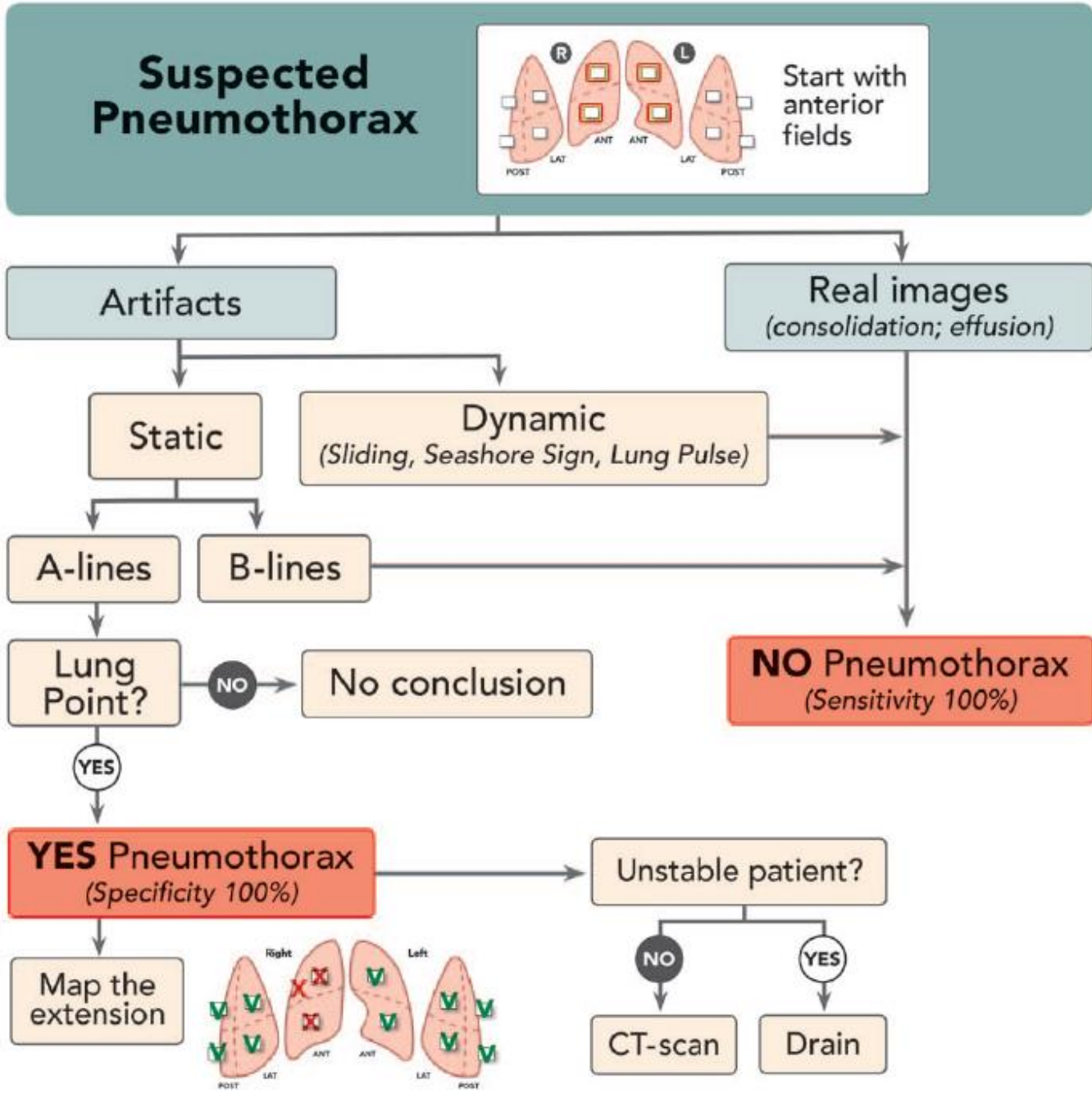
# How to look for the lung point





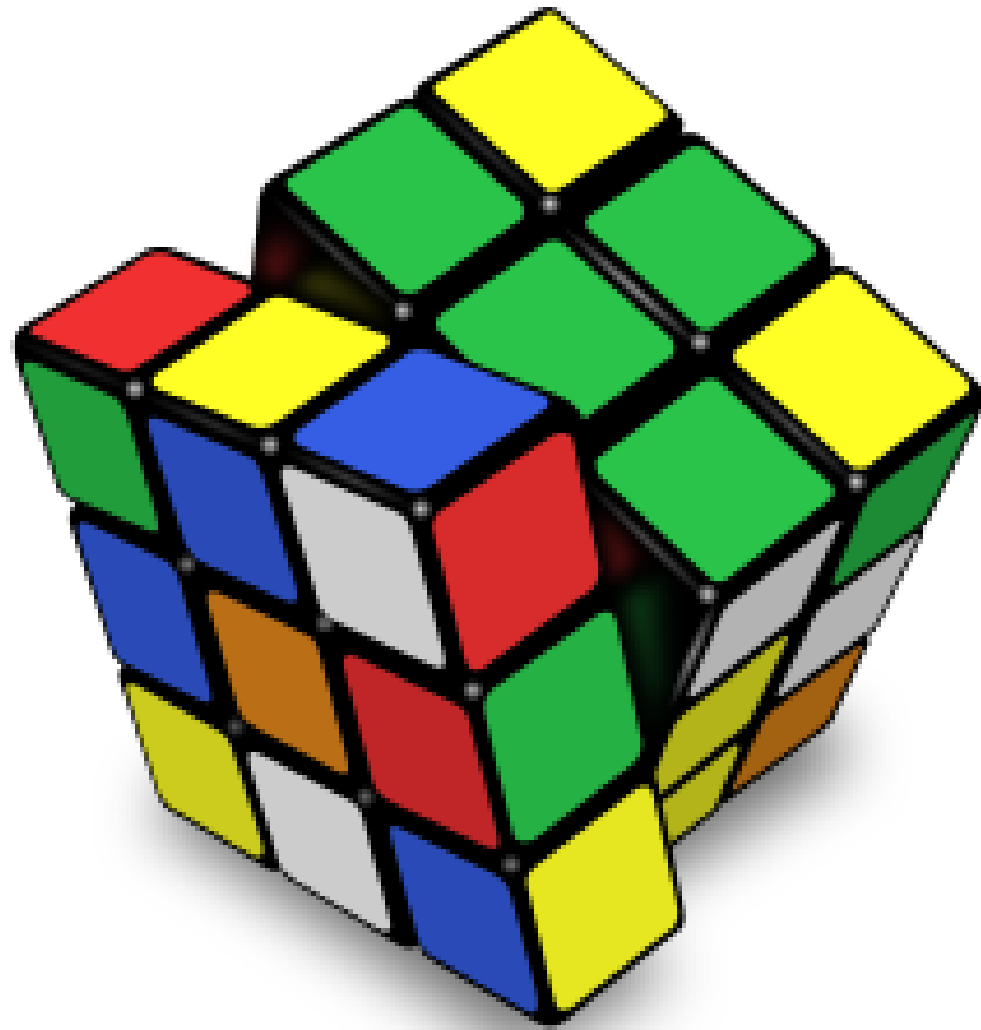
# How to look for the lung point





Bouhemad and Mongodi  
Anesthesiology 2015; 122:437-47





**Conclusion**

# Which Probe I should use

Vascular Probe  
(10-12 MgHz)



Cardiac Probe  
(4 MgHz)



Abdominal Probe  
(2 MgHz)



# Echographie pulmonaire

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- 1) Glissement pleural, lignes A et B, consolidation**
- 2) Degres de la perte d'aération**
- 3) Examen complet**





