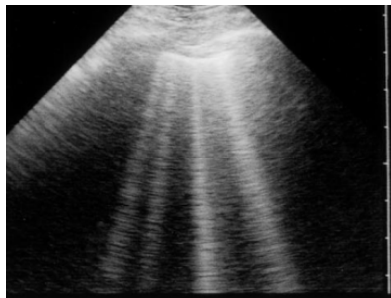




Introduction to FOCUS in hemodynamic instability: bedside lung ultrasound

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Département d'anesthésiologie
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Service des soins intensifs
Centre Hospitalier Universitaire de Montréal

**3rd LATIN AMERICAN COURSE ON
PERIOPERATIVE ECHOCARDIOGRAPHY AND ULTRASOUND
Bogota 2012**



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Chapter 235. Diagnostic Procedures in Respiratory Disease

Steven E. Weinberger, Jeffrey M. Drazen

ULTRASOUND

Because ultrasound energy is rapidly dissipated in air, ultrasound imaging is not useful for evaluation of the pulmonary parenchyma. However, it is helpful in the detection and localization of pleural abnormalities and is often used as a guide to placement of a needle for sampling of pleural liquid (i.e., for thoracentesis).



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lung ultrasound or lung echography



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☐ [Point of care ultrasound: the visual stethoscope of the 21st century.](#)

1. Gillman LM, Kirkpatrick AW.

Scand J Trauma Resusc Emerg Med. 2012 Mar 9;20(1):18. [Epub ahead of print]

PMID: 22400903 [PubMed - as supplied by publisher]

[Related citations](#)

Comparative Diagnostic Performances of Auscultation, Chest Radiography, and Lung Ultrasonography in Acute Respiratory Distress Syndrome

Daniel Lichtenstein, M.D.,* Ivan Goldstein, M.D.,† Eric Mourgeon, M.D.,† Philippe Cluzel, M.D., Ph.D.,‡
Philippe Grenier, M.D.,§ Jean-Jacques Rouby, M.D., Ph.D.||

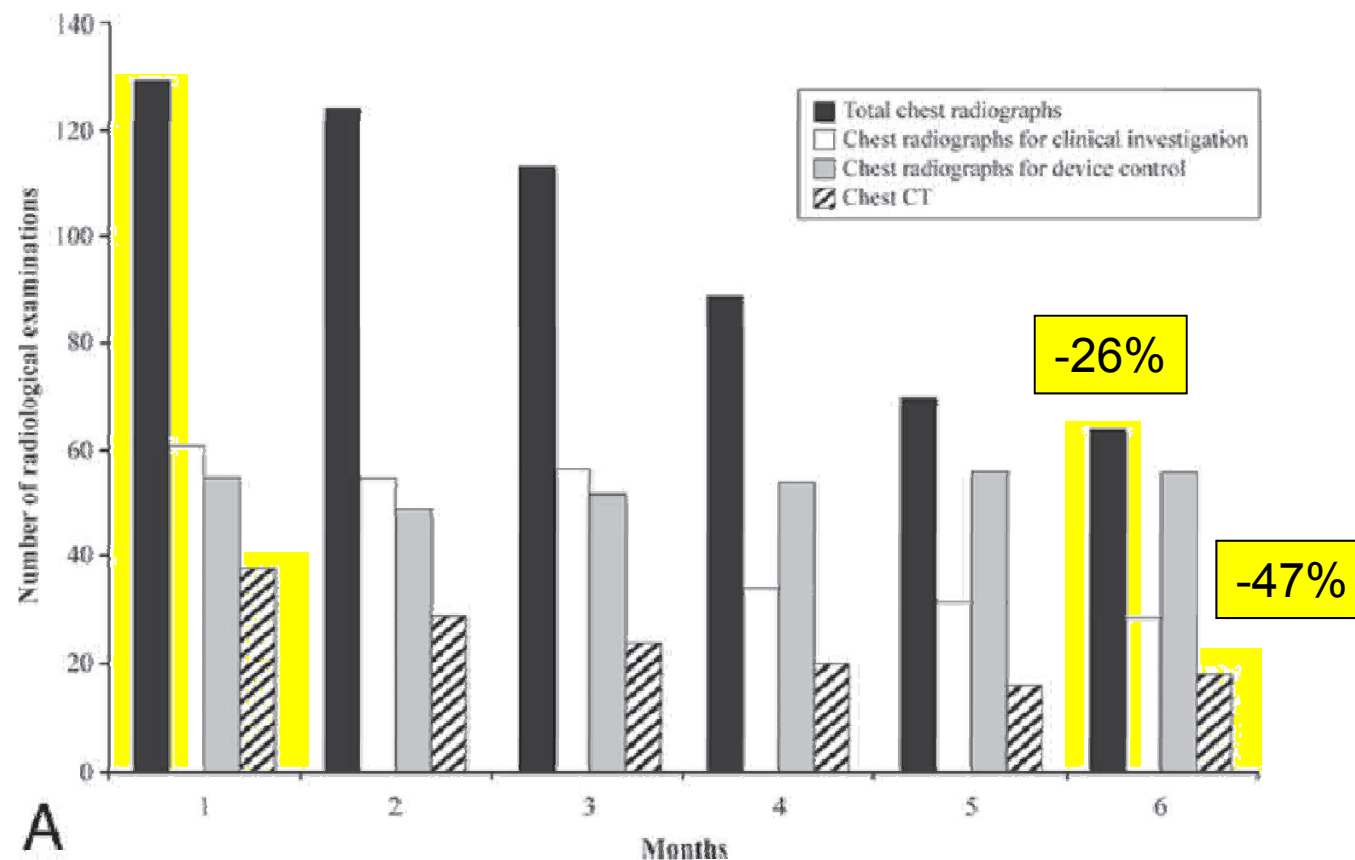
Table 1. Sensitivity and Specificity of Auscultation, Chest Radiography, and Lung Ultrasonography for Diagnosing Pleural Effusion, Alveolar Consolidation, and Alveolar-Interstitial Syndrome in 384 Lung Regions in 32 Critically Ill Patients with ARDS

	Auscultation, %	Chest Radiography, %	Lung Ultrasonography, %
Pleural effusion			
Sensitivity	42	39	92
Specificity	90	85	93
Diagnostic accuracy	61	47	93
Alveolar consolidation			
Sensitivity	8	68	93
Specificity	100	95	100
Diagnostic accuracy	36	75	97
Alveolar-interstitial syndrome			
Sensitivity	34	60	98
Specificity	90	100	88
Diagnostic accuracy	55	72	95

ARDS = acute respiratory distress syndrome.

The Use of Point-of-Care Bedside Lung Ultrasound Significantly Reduces the Number of Radiographs and Computed Tomography Scans in Critically Ill Patients

Adriano Peris, MD,* Lorenzo Tutino, MD,* Giovanni Zagli, MD,* Stefano Batacchi, MD,* Giovanni Cianchi, MD,* Rosario Spina, MD,* Manuela Bonizzoli, MD,* Luisa Migliaccio, MD,* Lucia Perretta, MD,* Marco Bartolini, MD,† Kevin Ban, MD,‡ and Martin Balik, MD, PhD§



A





CHEST

Consensus Statement

American College of Chest Physicians/ La Société de Réanimation de Langue Française Statement on Competence in Critical Care Ultrasonography*

*Paul H. Mayo, MD; Yannick Beaulieu, MD; Peter Doelken, MD;
David Feller-Kopman, MD; Christopher Harrod, MS; Adolfo Kaplan, MD;
John Oropello, MD; Antoine Vieillard-Baron, MD; Olivier Axler, MD;
Daniel Lichtenstein, MD; Eric Maury, MD; Michel Slama, MD;
and Philippe Vignon, MD*

(CHEST 2009; 135:1050–1060)

Table 2—*Technical (Image Acquisition) and Cognitive (Image Interpretation) Elements Required for Competence in Lung Ultrasonography*

Knowledge of the basic semiology of lung ultrasound: A-lines, B-lines, sliding lung, lung point

Identification and characterization of consolidated lung:
identification of tissue density lung, with or without air bronchograms

Identification and characterization of air artifacts suggestive of the normal aeration pattern: A-lines with sliding lung

Identification and characterization of air artifacts suggestive of alveolar interstitial pattern: number and location of B lines

Knowledge of the limitations of not visualizing lung sliding/B lines

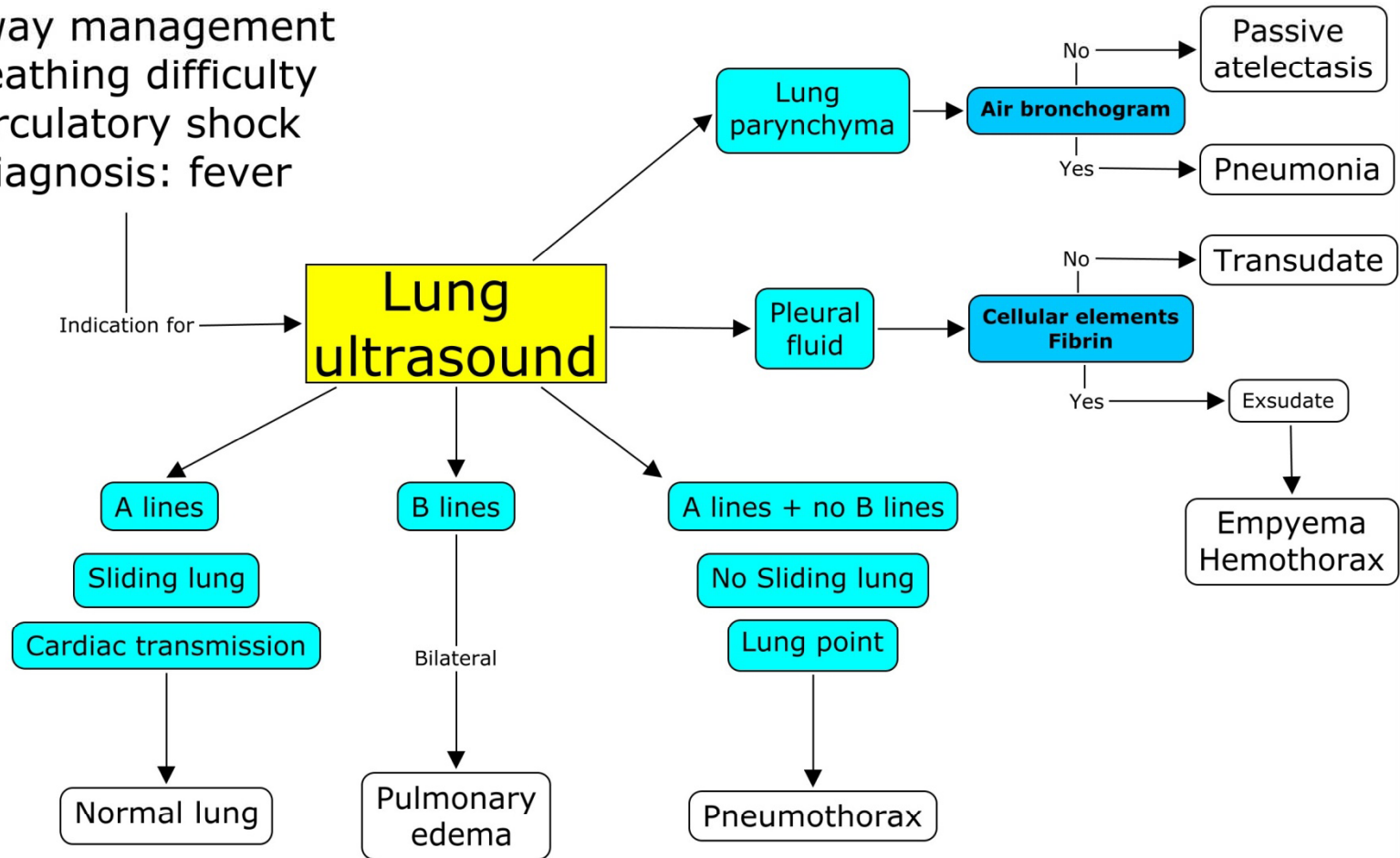
Identification and characterization of air artifacts to rule out pneumothorax: presence of sliding lung, presence of B-lines

Identification and characterization of findings that rule in pneumothorax:
presence of lung point (both by 2D imaging and M-mode)

Our current approach

Airway management
Breathing difficulty
Circulatory shock
Diagnosis: fever

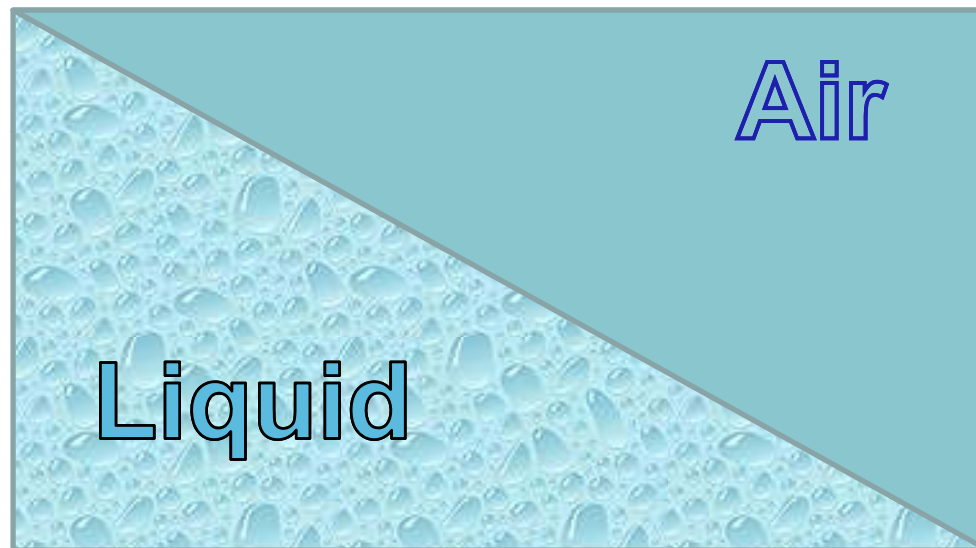
Indication for



Lung ultrasonography

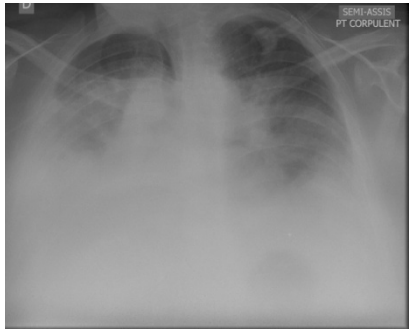
- Air/liquid interface with high acoustic impedance from which arise artifacts
- First few centimeters are evaluated (chest wall, pleura, and lung parenchyma)
- The goal is not always the visualization of lung structures but the interpretation of acoustic artifacts

Content of the lung

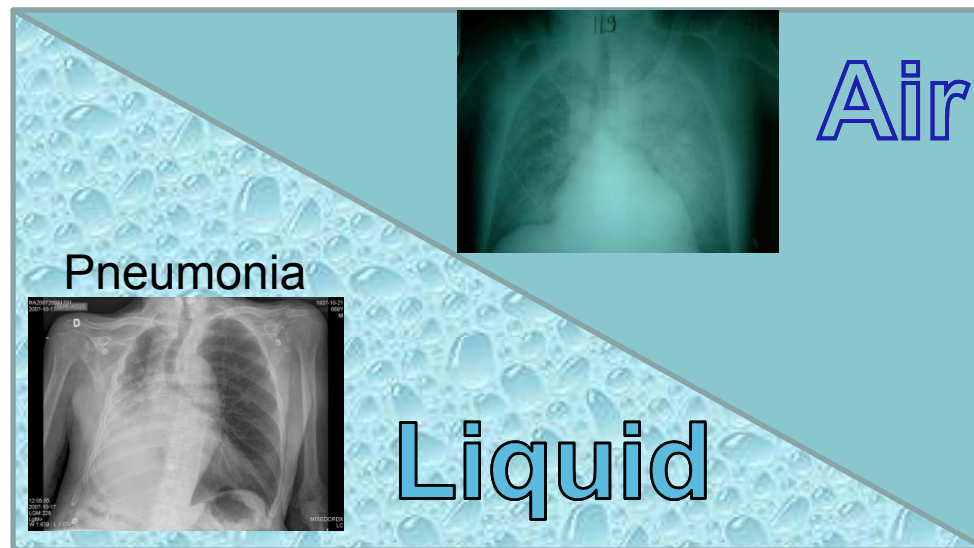


Content of the lung

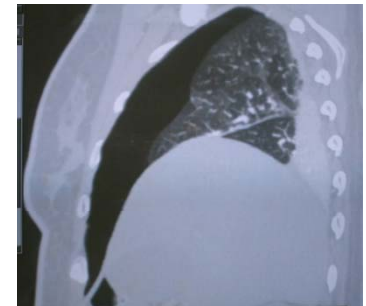
Pleural effusion



Interstitial edema

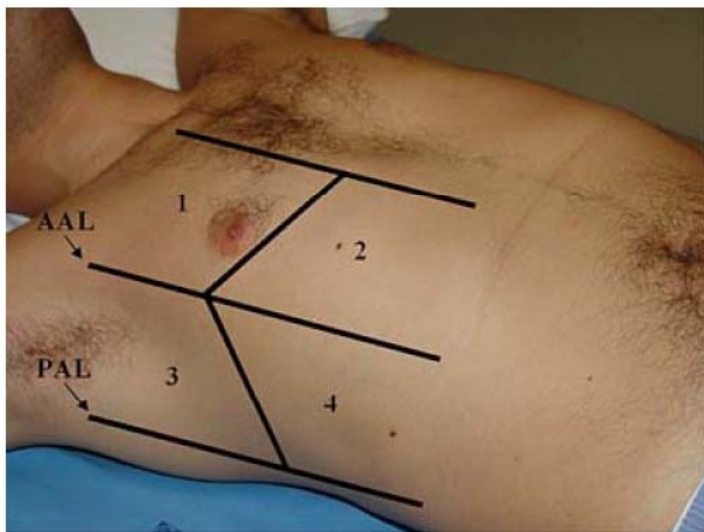


Pneumothorax



Pulmonary ultrasound: approach

- 1- Linear + phased-array transducer (3.5-10 MHz)
- 2- Low-moderate gain
- 3- 5-8 cm depth
- 4- Scan longitudinally the lung (4 to 6 regions/lung)
- 5- Complete with venous analysis

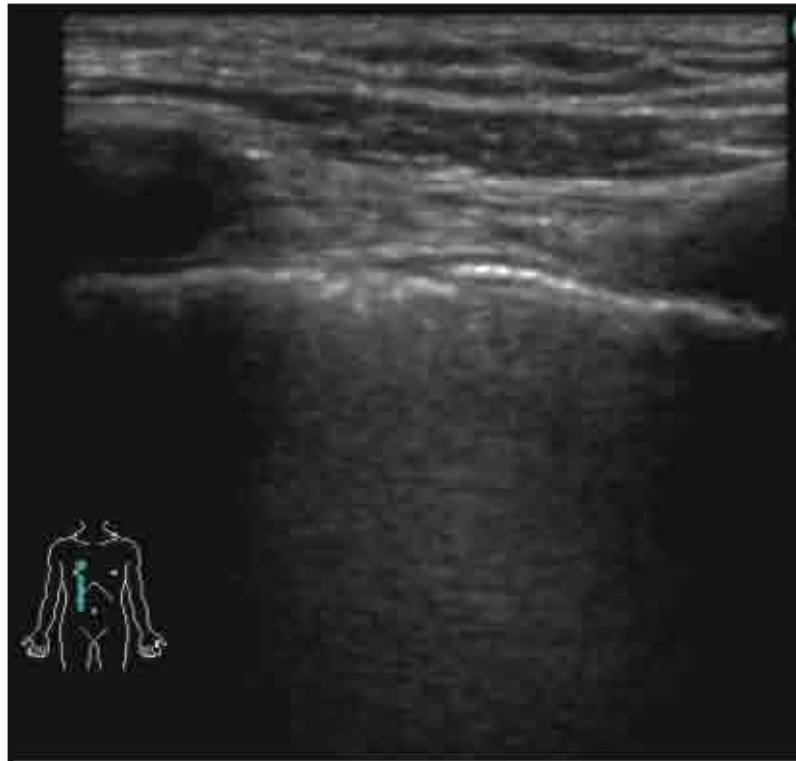


Anterior regions (1-2): pneumothorax (98%)
interstitial syndrome

Lateral regions (3-4): pleural effusion
consolidations
phrenic nerve function

Nomenclature: sliding lung

- Horizontal movement of the pleural line
- 5 mm below the rib line
- Hyperechoic (white)
- Moves with respiration
- Maximal amplitude on the base of the lung
- Corresponds to the movement of the visceral pleura on the parietal pleura





Nomenclature: A lines

- Hyperechoic horizontal lines arising from the pleural line
 - Parallel and exact distance from the probe to the pleural line
 - Repeated multiple time
- = reverberation of the pleural line

A lines + sliding lung = normal aerated and ventilated lung

DAO
Gen MB

ST-LUC

2008Jul27 14:51

QSD



Vas
HFL



96%

14

34

MI

0.7



68



6.0

190bpm

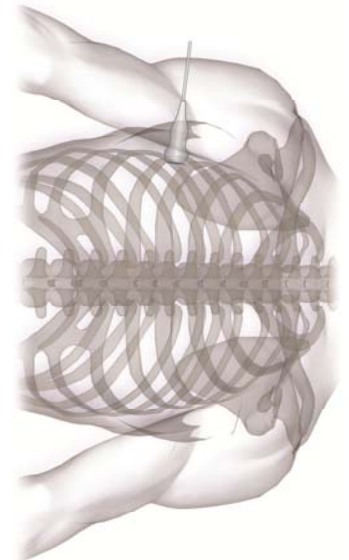




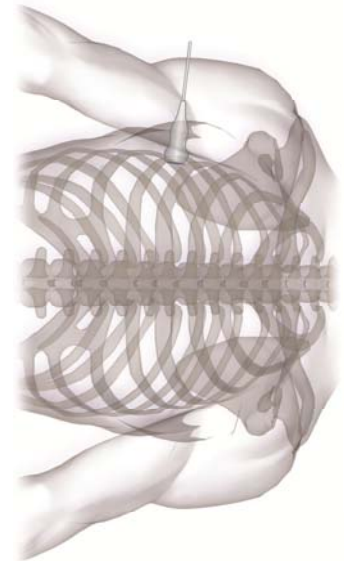
Thoracic ultrasound: sliding lung



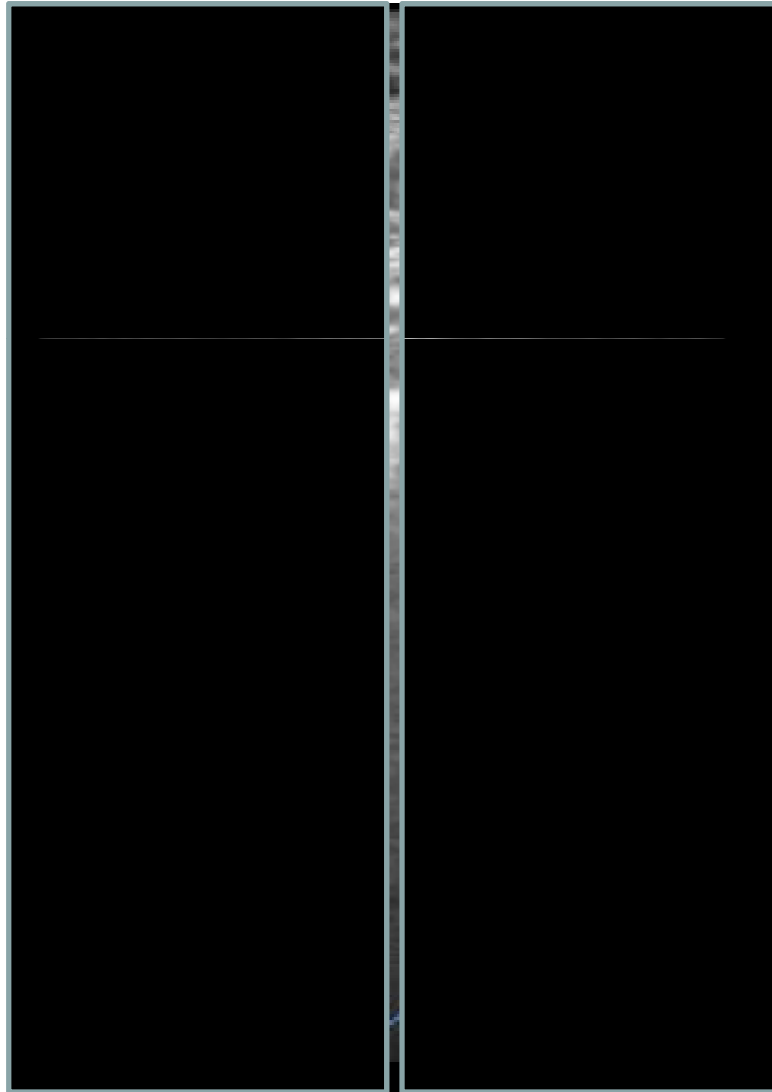
Sliding lung



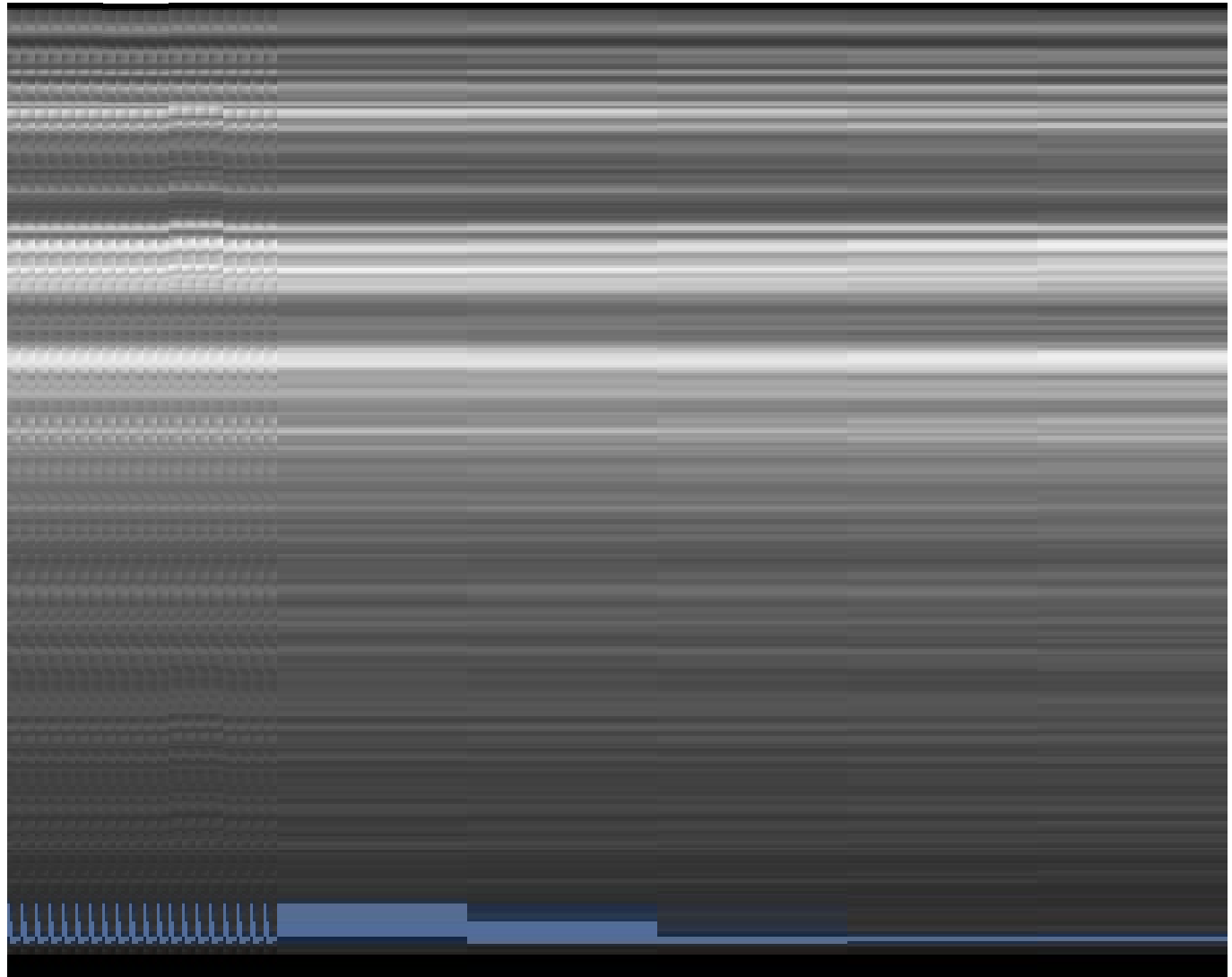
Sliding lung

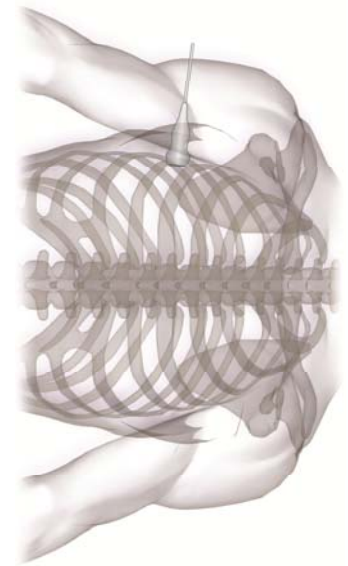
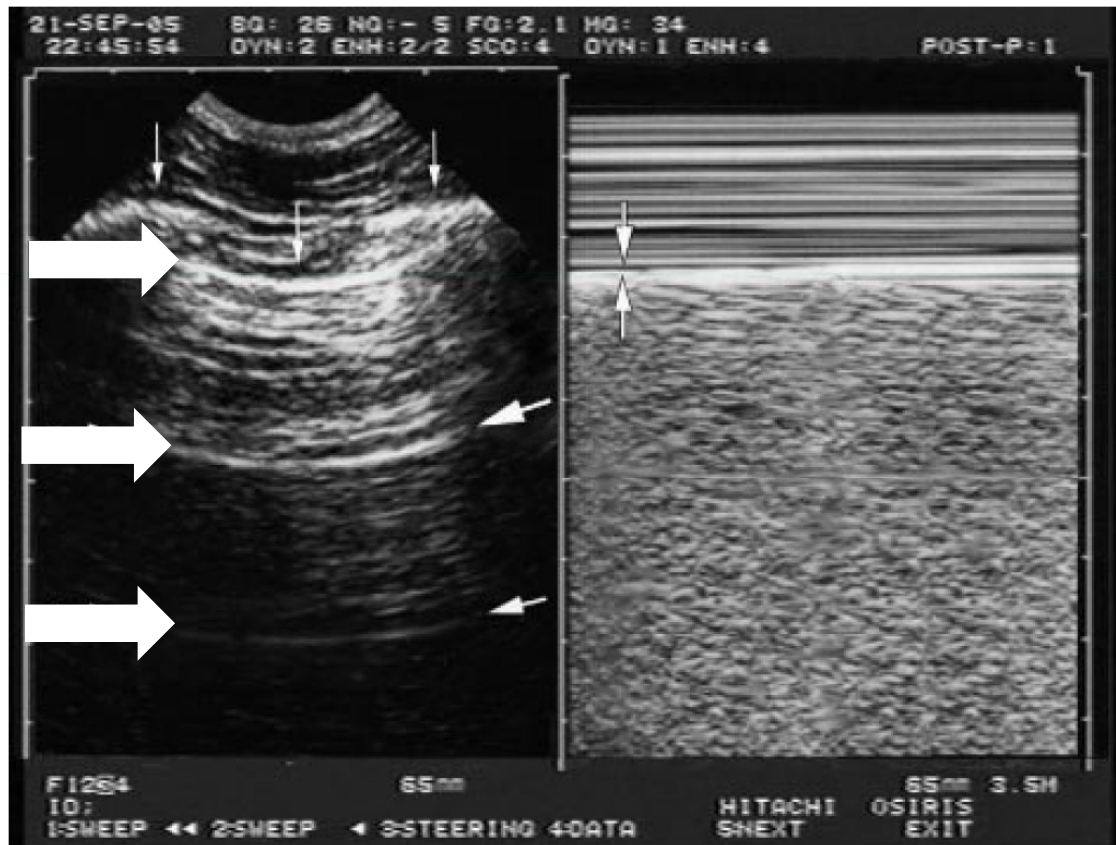


2D and M mode



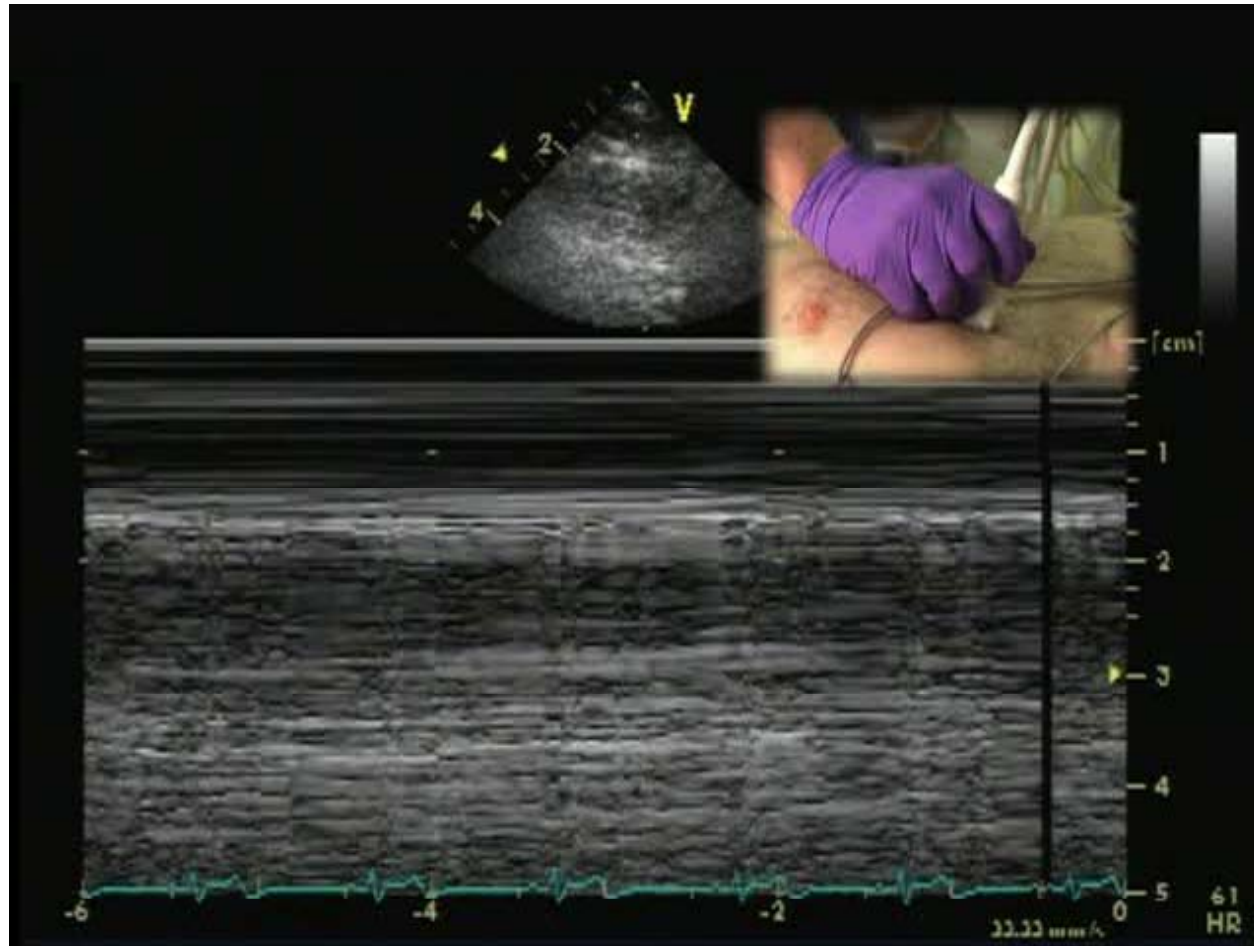
Mode 2D et mode M



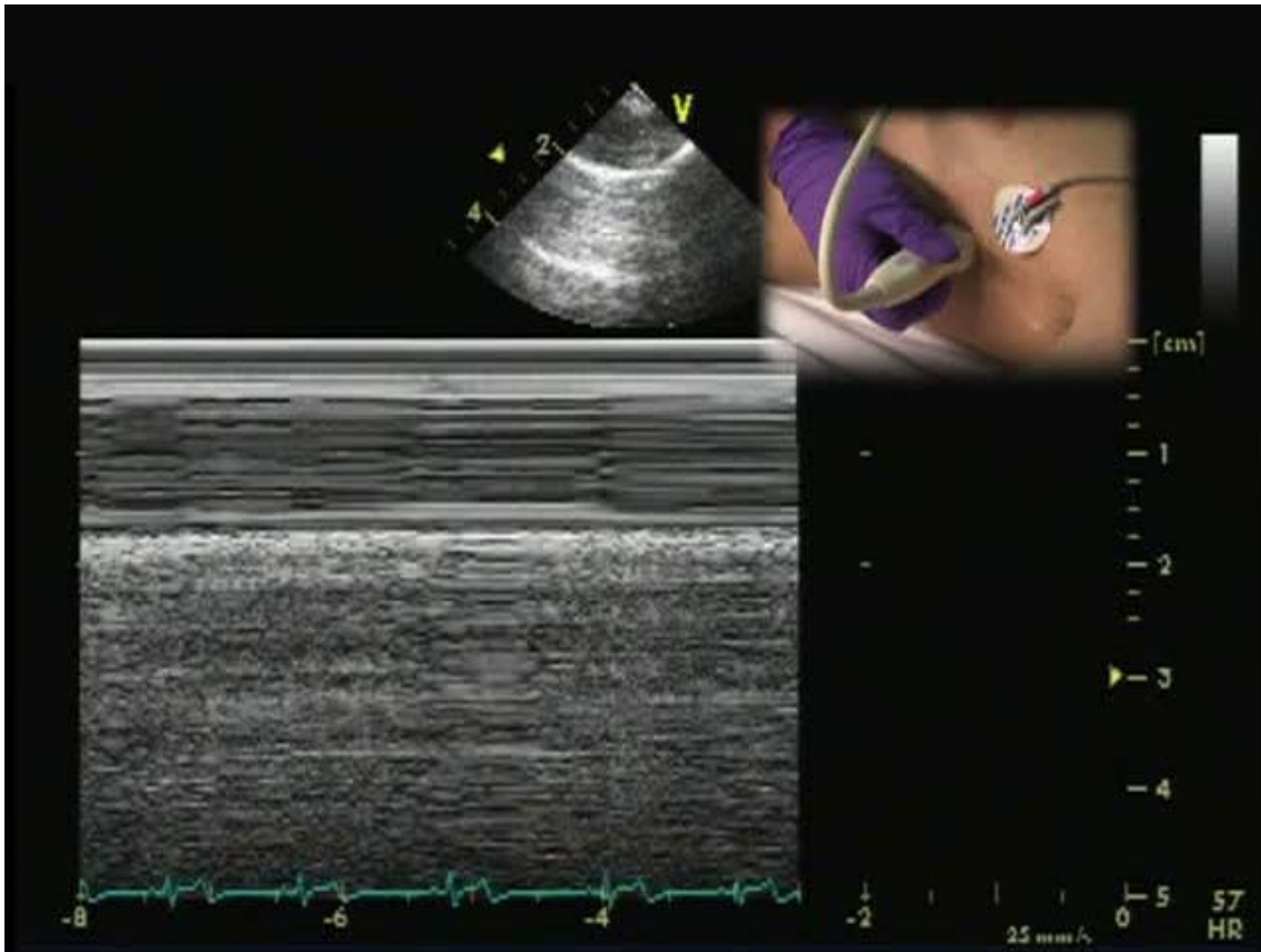


A lines = repetitive horizontal artifacts arisin from the pleural line
 Lung dynamics generate lung sliding (sandy pattern).
 This pattern is called the *seashore sign*

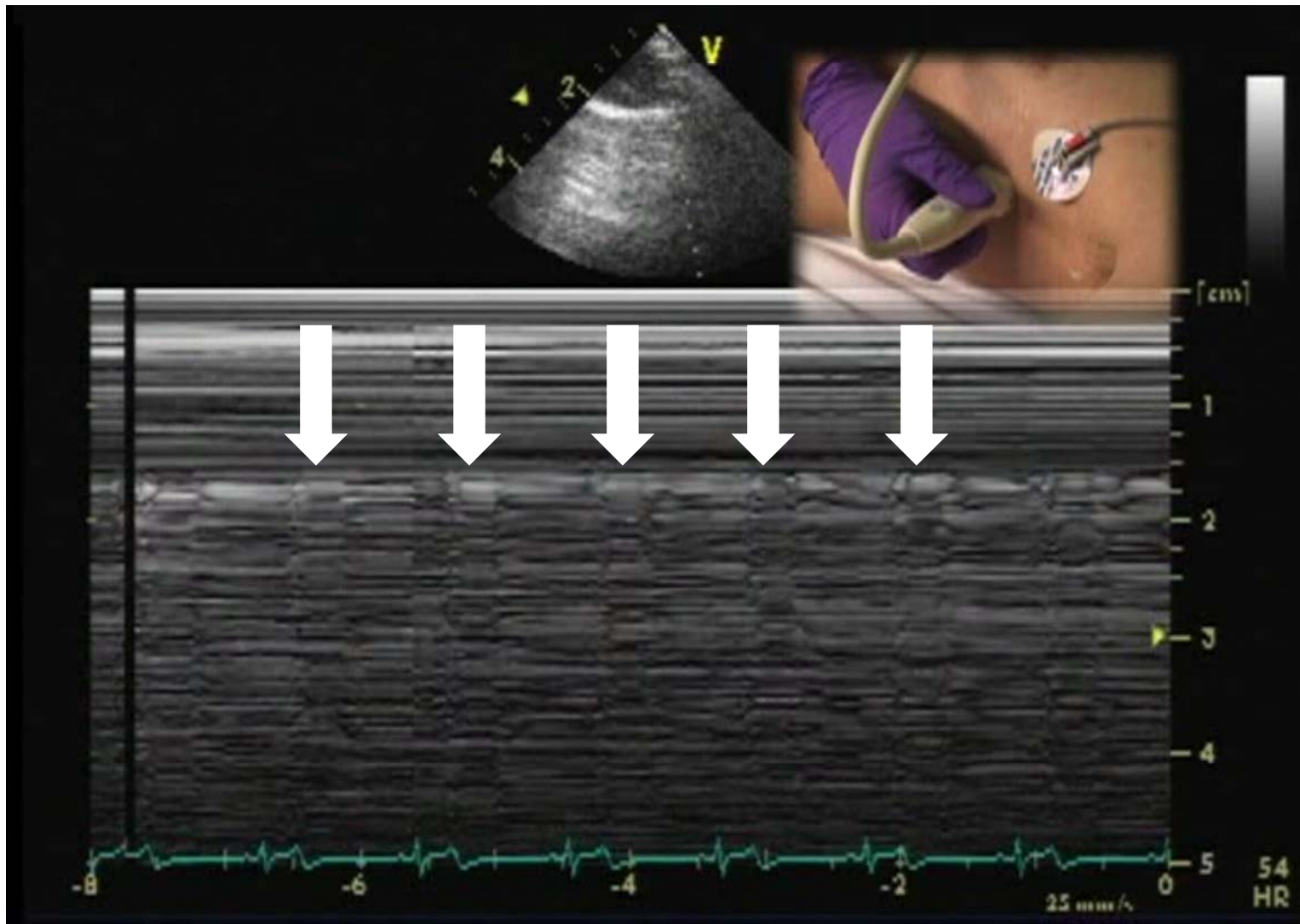
Mmode



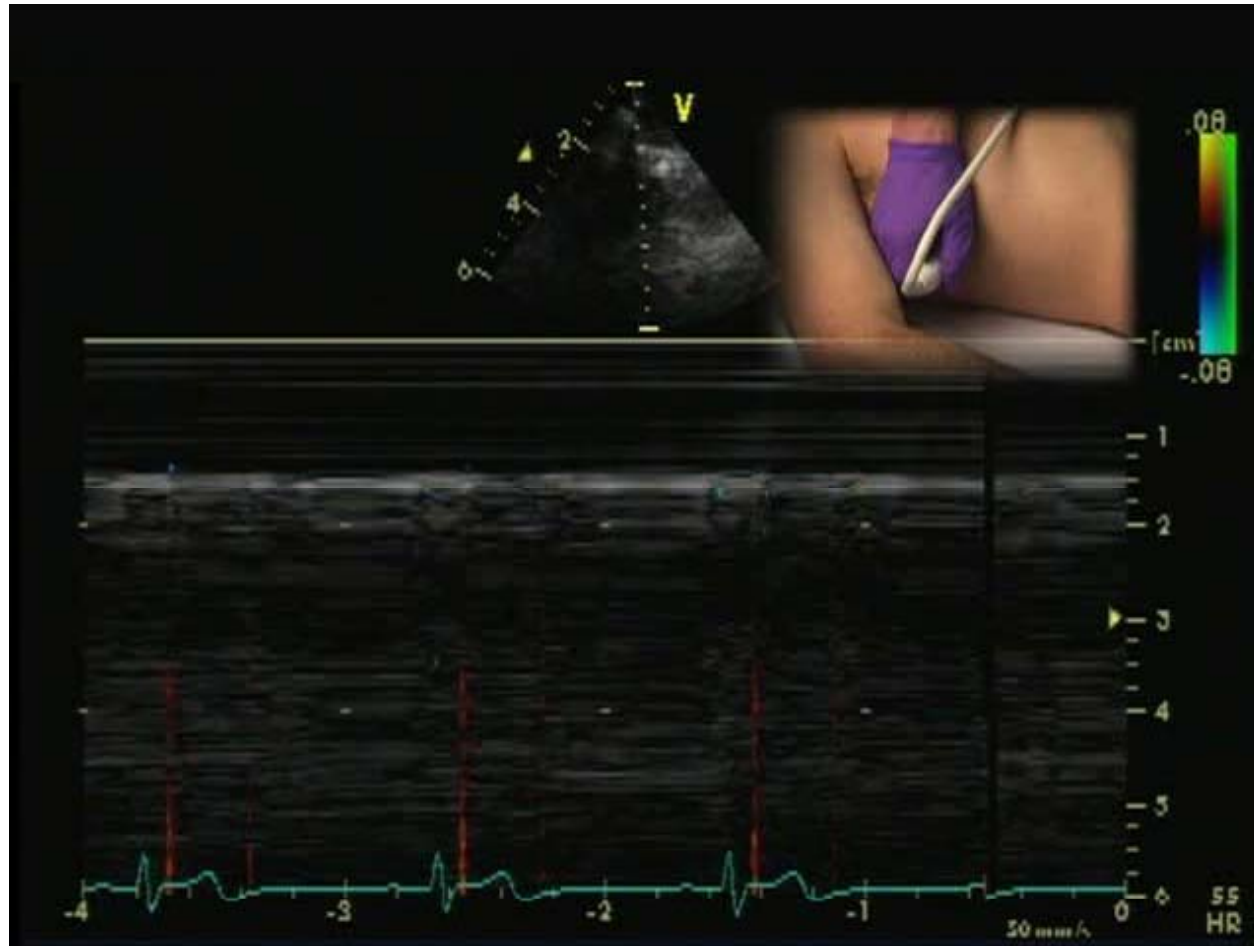
Not breathing on Mmode: cardiac pulsations = lung pulse



Mmode: heart beat



Mmode + color: lung pulse

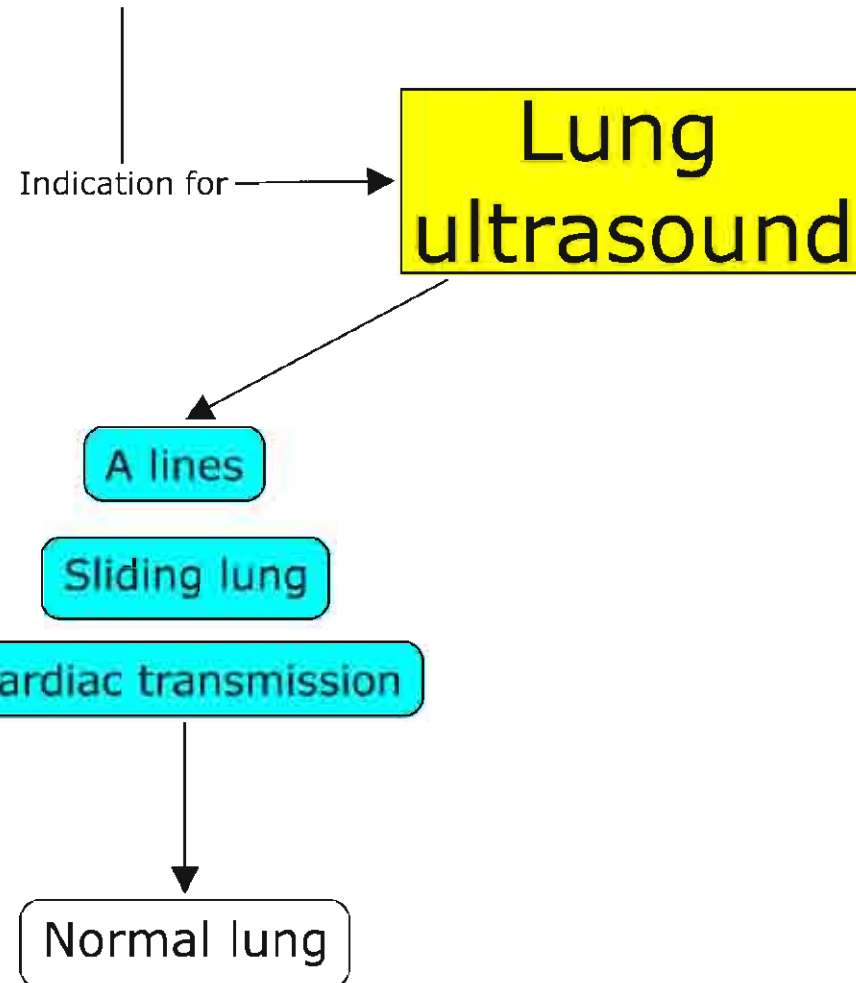


Airway management

- With right stem bronchus intubation:
 - ✓ Sliding lung will be observed on the right
 - ✓ No sliding lung will be observed on the left
 - ✓ Lung pulse on the left within seconds
 - ✓ Exaggerated diaphragmatic excursion on the right

The lung pulse has a sensitivity of 90% for the diagnosis of one-lung intubation

Airway management
Breathing difficulty
Circulatory shock
Diagnosis: fever



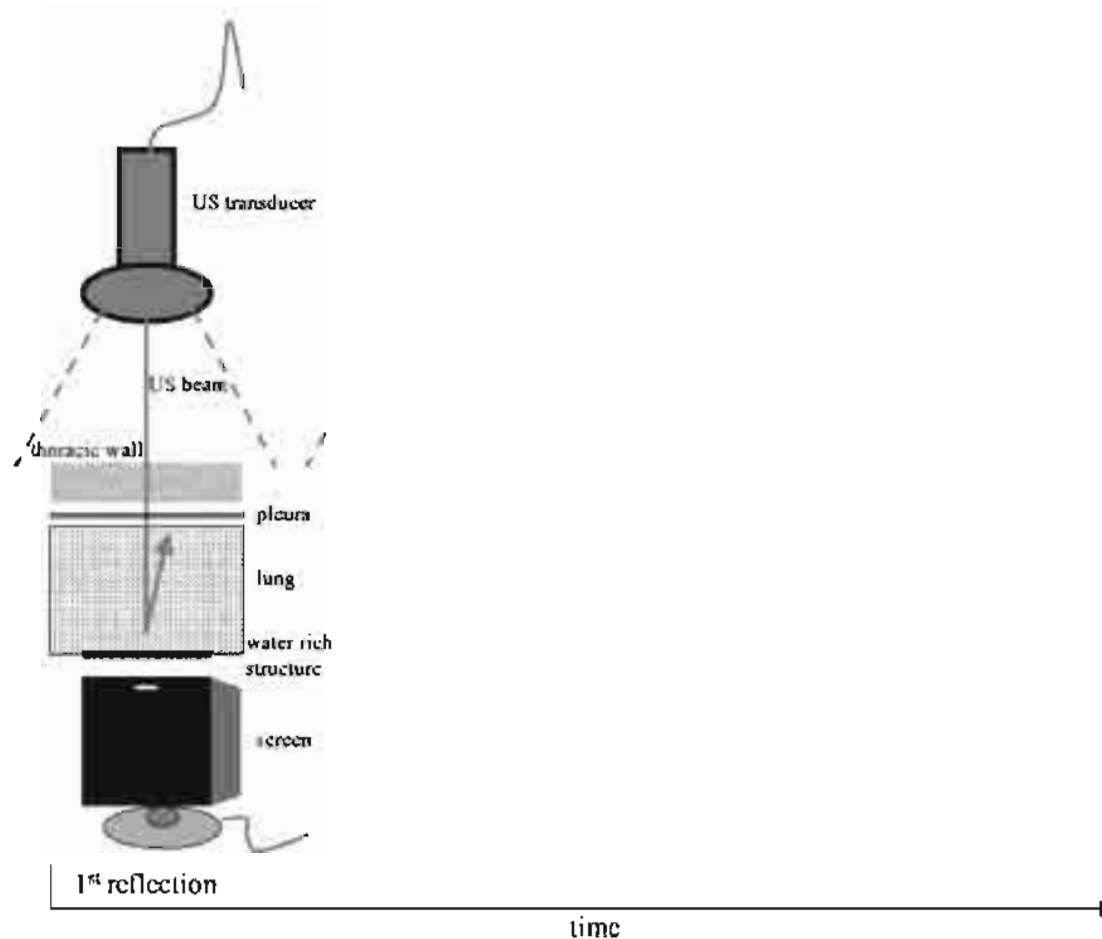
Nomenclature: B lines or comet tails

- Hyperechoic vertical lines arising from the pleural line
- Perpendicular to the pleural line and reach the edge of the screen
- Erases the A line
- Moves with lung sliding
- Normal: single in the anterior lung
(1/3 patients with B lines in the 10th or 11th intercostal space)

Usefulness of lung ultrasound in the bedside distinction between pulmonary edema and exacerbation of COPD

Giovanni Volpicelli • Luciano Cardinale •

Giorgio Garofalo • Andrea Veltri



Early detection of acute lung injury uncoupled to hypoxemia in pigs using ultrasound lung comets*

Luna Gargani, MD; Vincenzo Lionetti, MD; Claudio Di Cristofano, MD; Generoso Bevilacqua, MD, PhD; Fabio A. Recchia, MD, PhD; Eugenio Picano, MD, PhD, FESC

Black Lung
(ULCs=0-5)

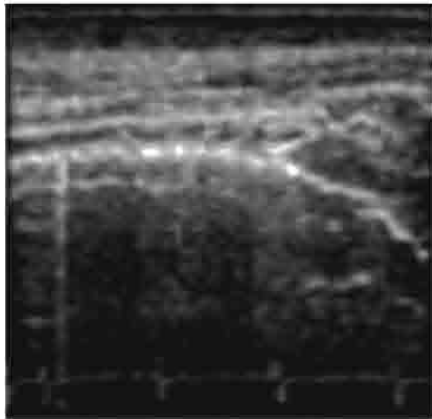
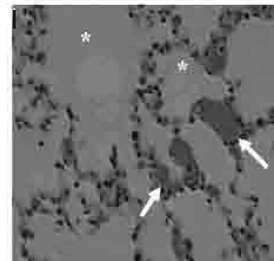
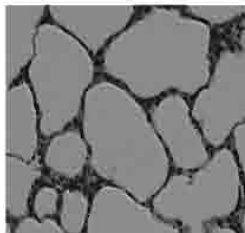
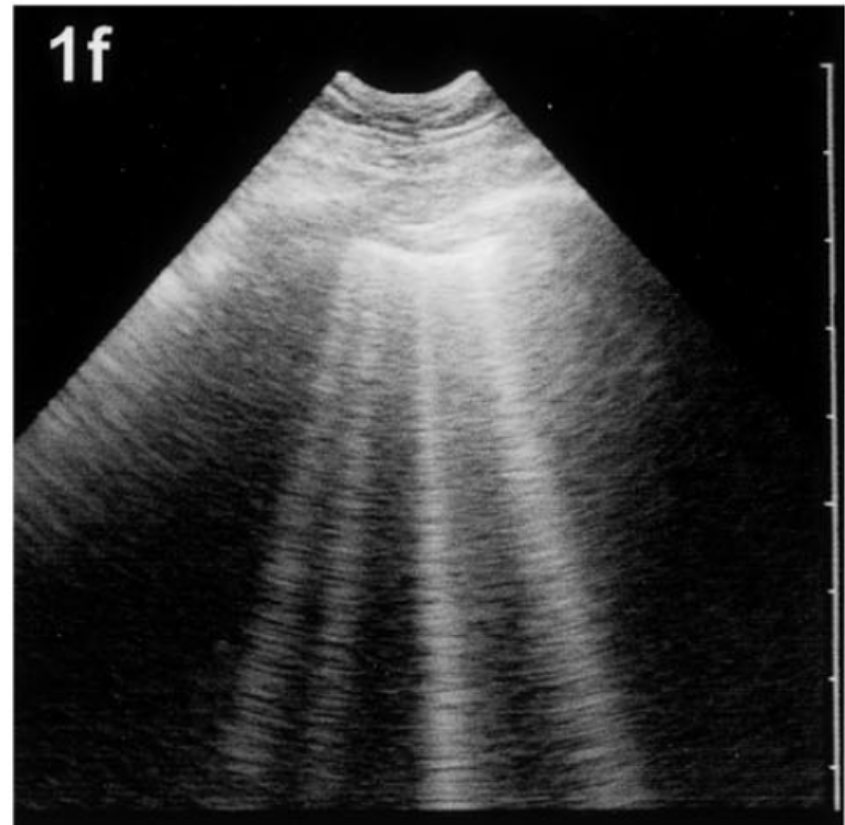
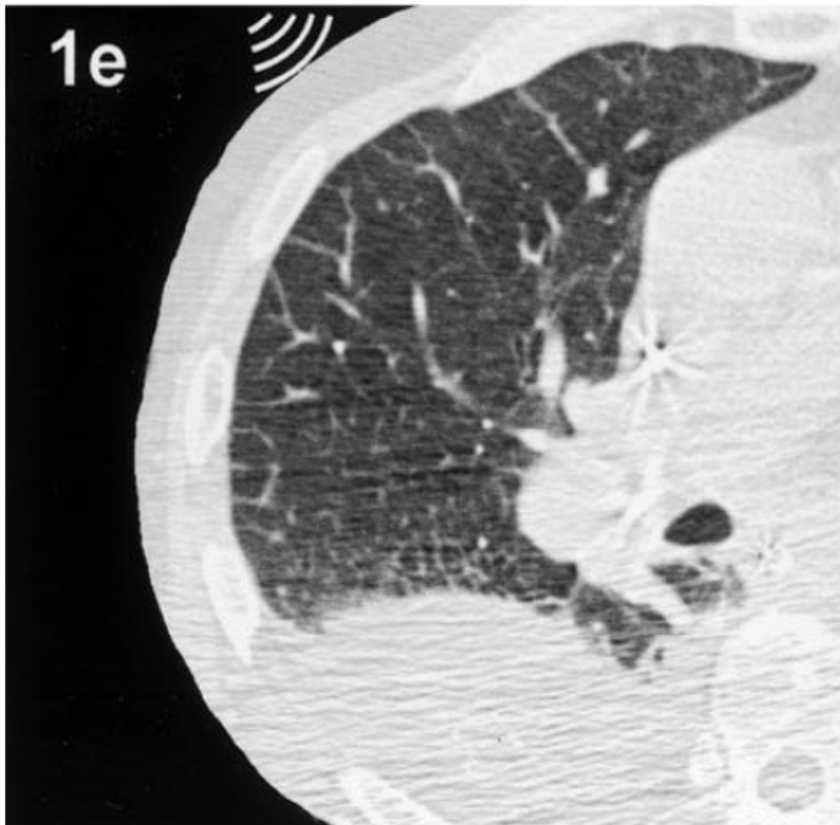


Figure 3. Different chest sonography patterns. *ULCs*, ultrasound lung comets.

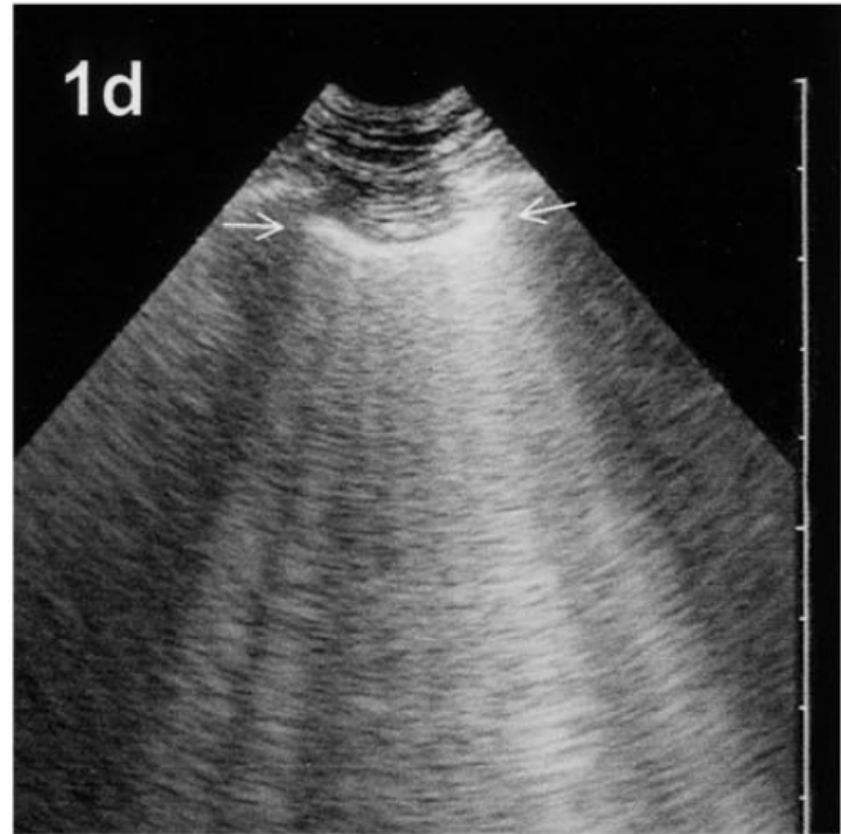
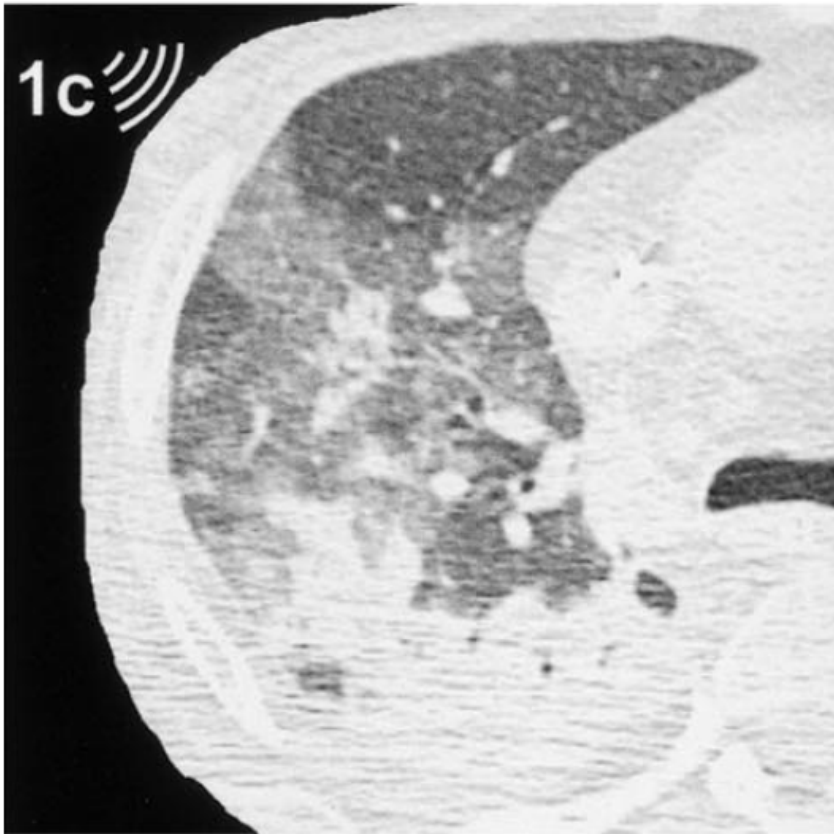


(Crit Care Med 2007; 35:2769–2774)

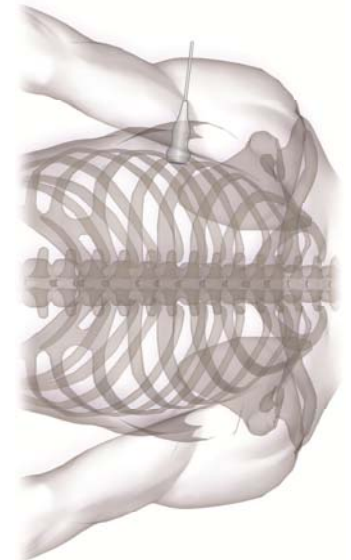
Pulmonary edema: 7 ± 1 mm between tails

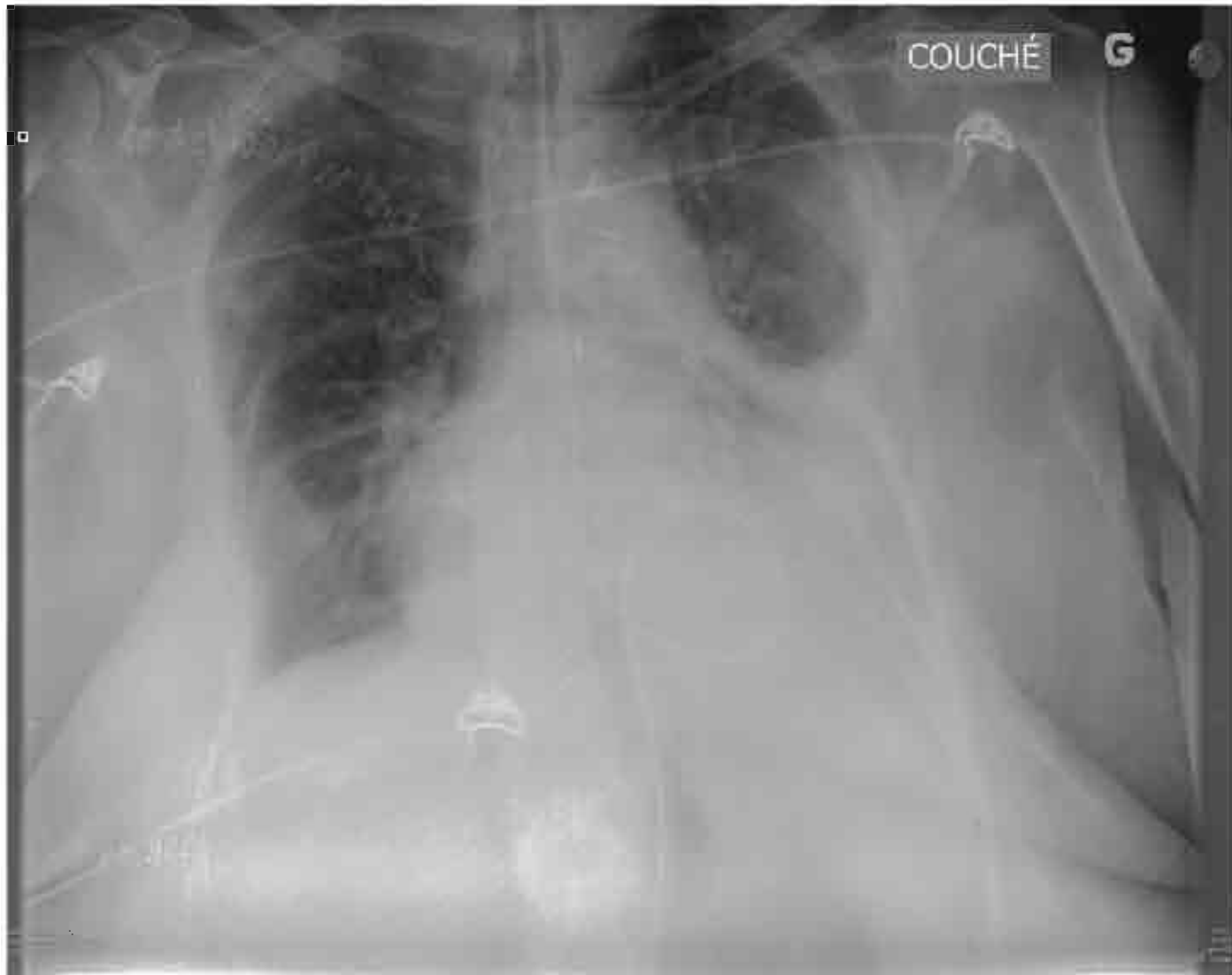


Pulmonary edema: < 3mm between tails

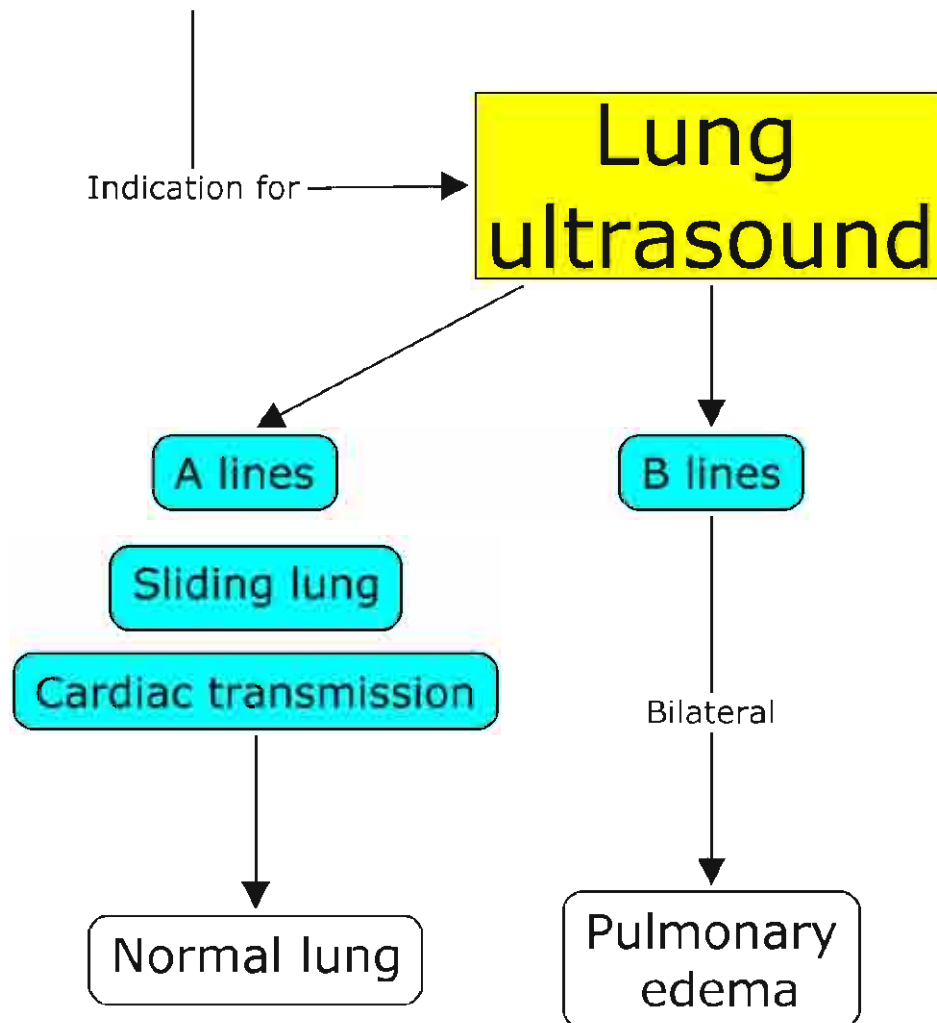


Bilateral B lines Chest X ray?





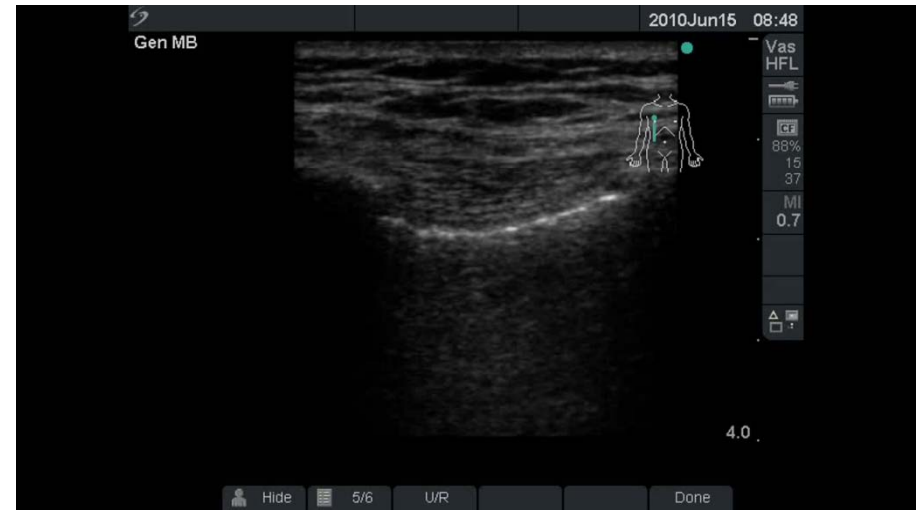
Airway management
Breathing difficulty
Circulatory shock
Diagnosis: fever



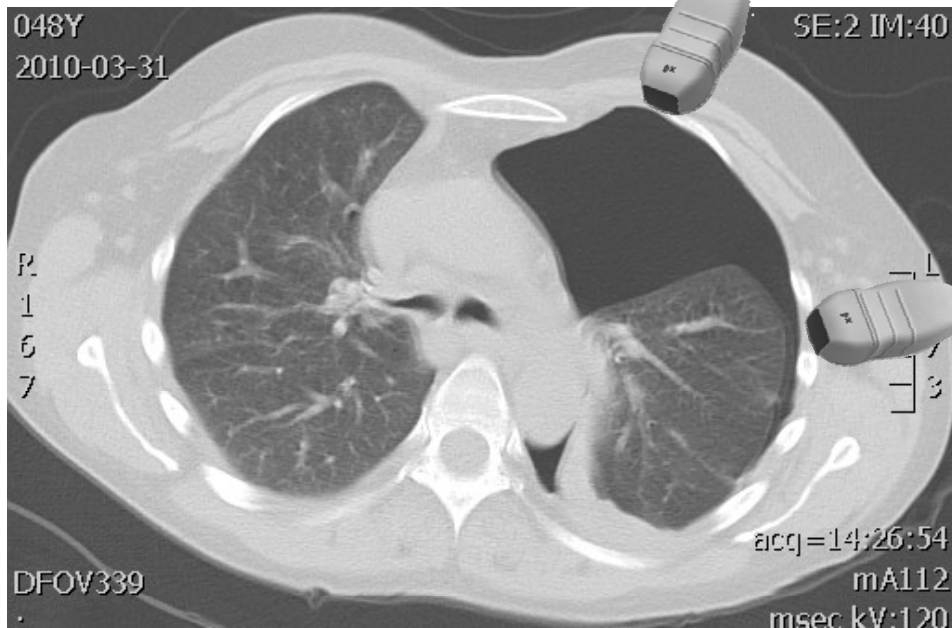
Diagnosis: pneumothorax

- Criterias
 - ✓ A lines only
 - ✓ Lung-point sign
- Ruled-out if: (***) at the site of examination)
 - ✓ Sliding lung present
 - ✓ B lines or comet tails present
 - ✓ Cardiac transmission up to the pleural line or lung pulse

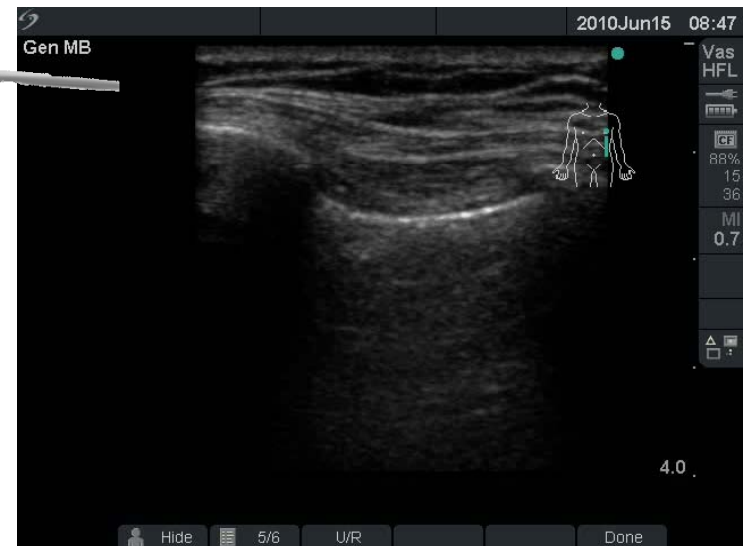
Lung point



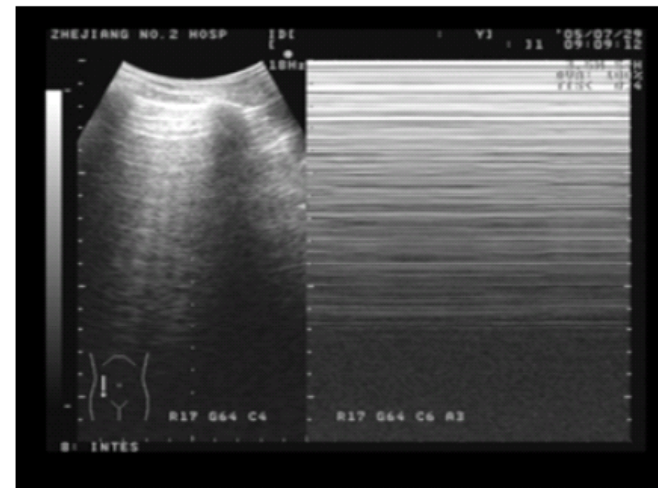
No sliding lung



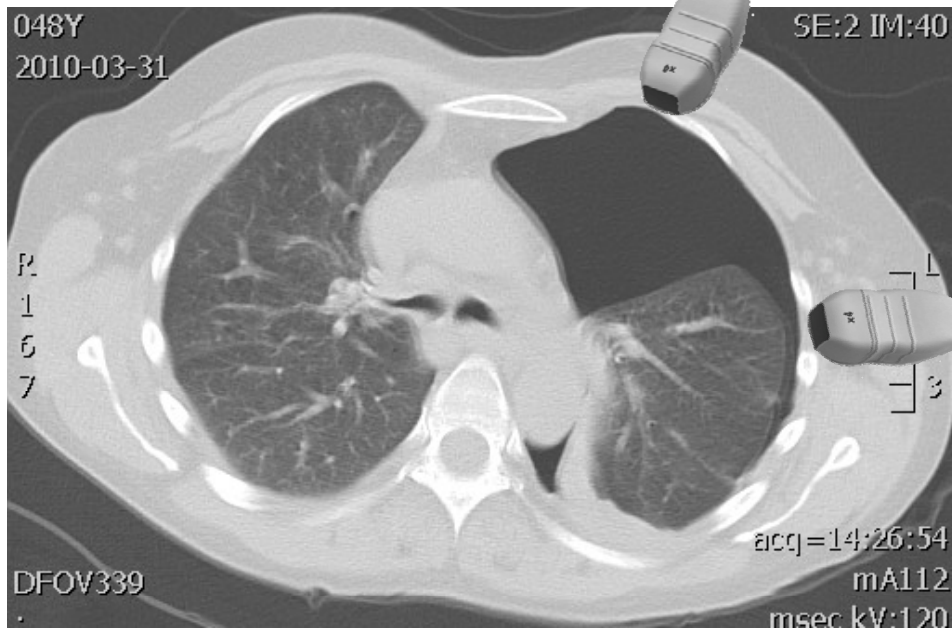
Sliding lung



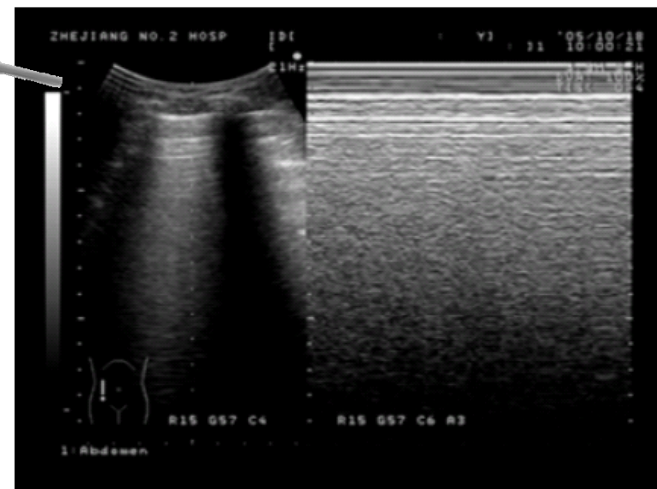
Lung point



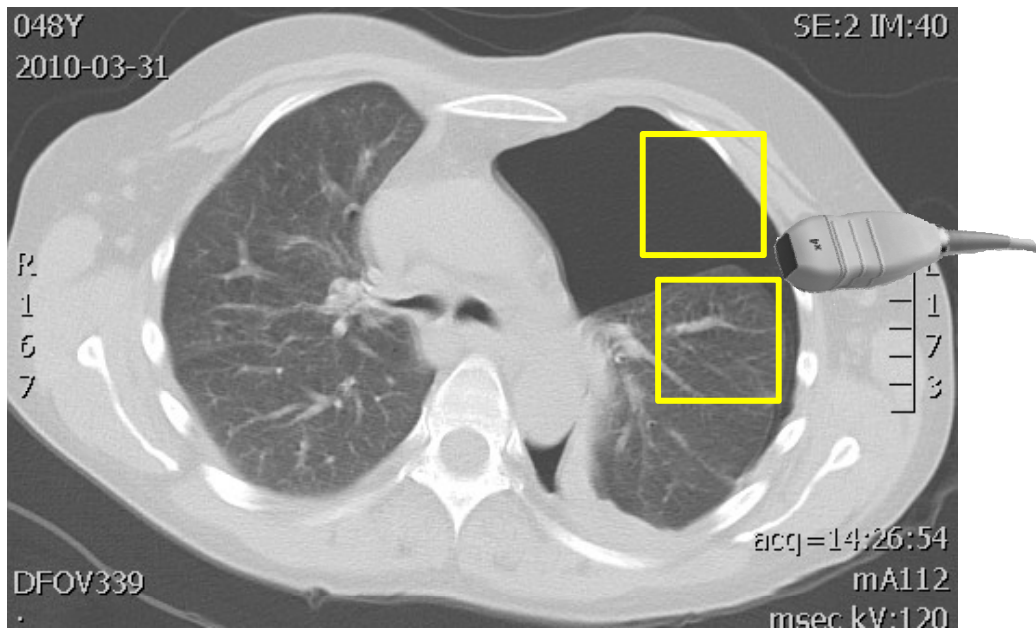
No sliding lung



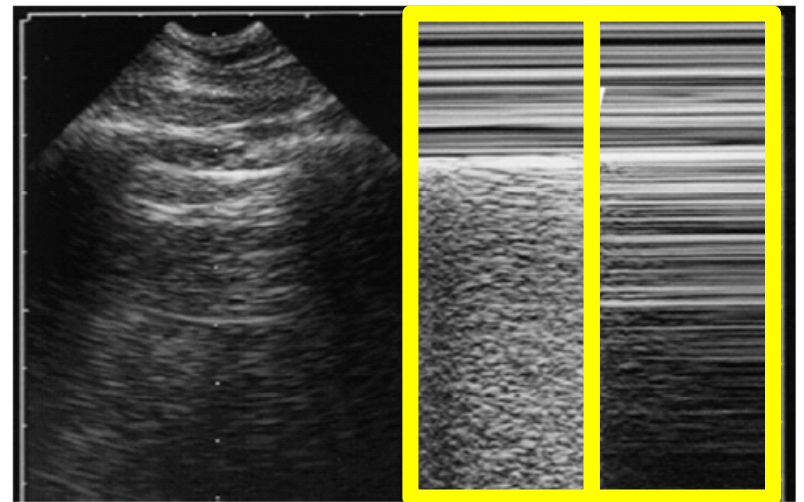
Sliding lung



Lung point

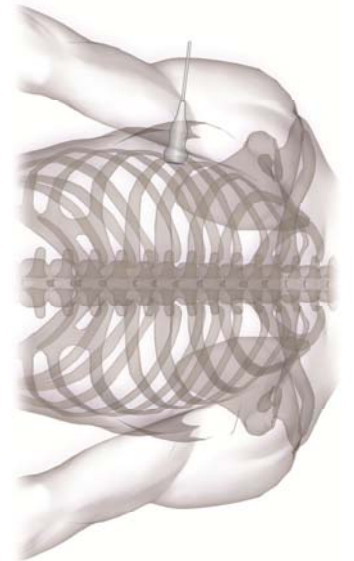
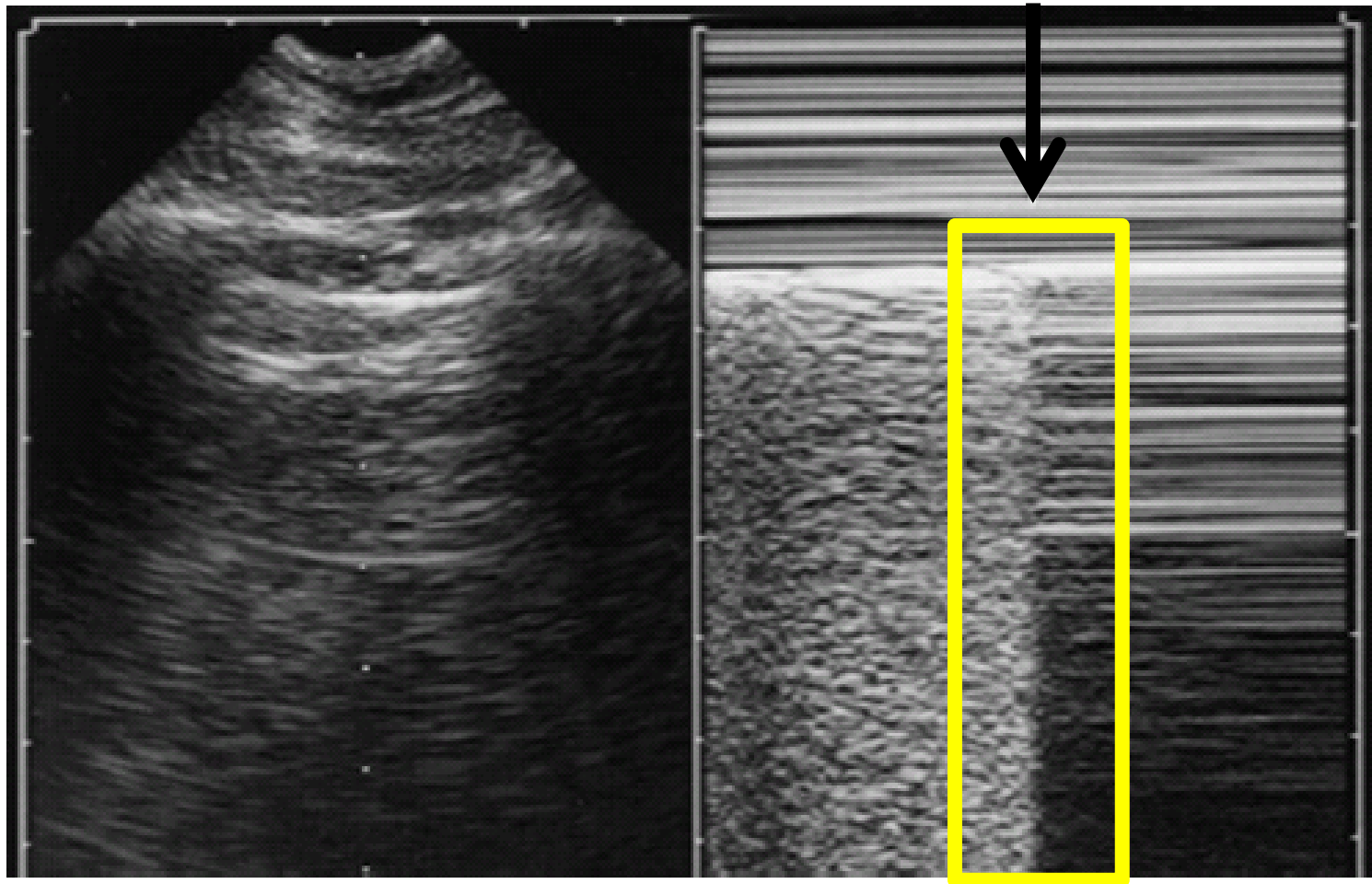


No sliding lung

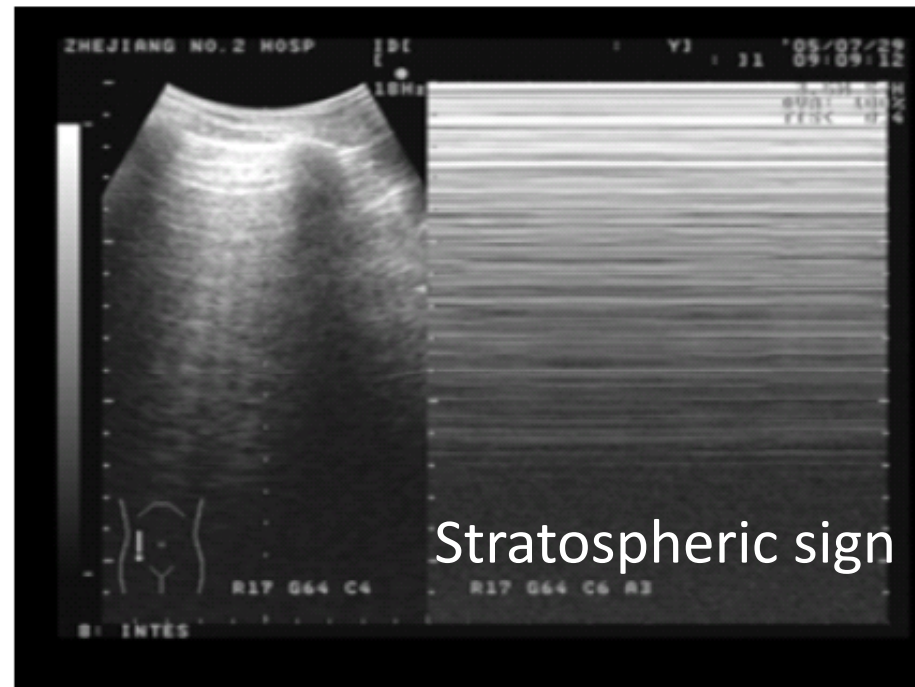
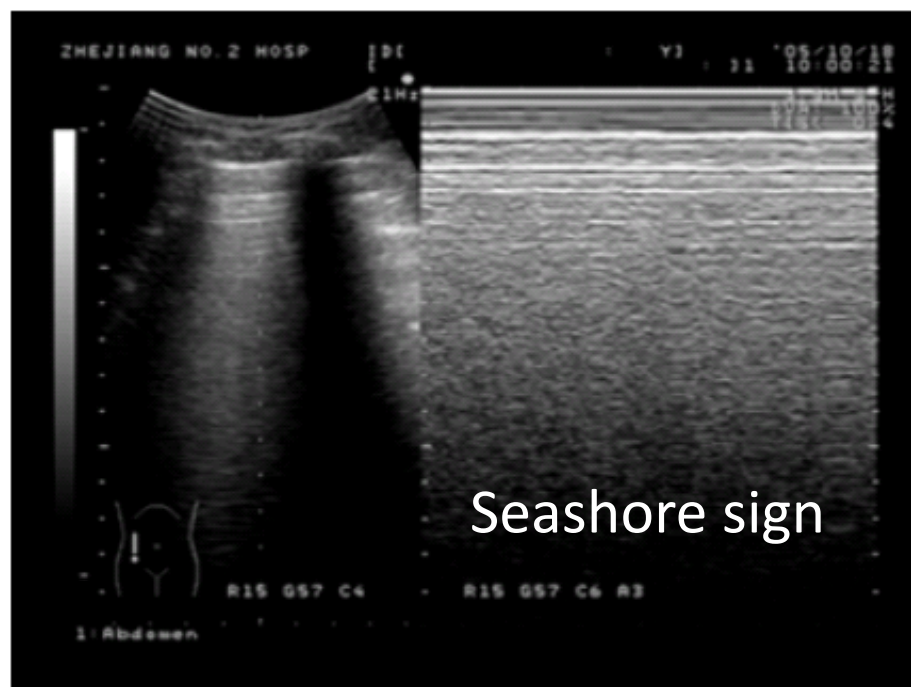


Sliding lung

Lung point



Rapid detection of pneumothorax by ultrasonography in patients with multiple trauma



Surgeon-Performed Ultrasound for Pneumothorax in the Trauma Suite

Jason L. Knudtson, MD, Jonathan M. Dort, MD, FACS, Stephen D. Helmer, PhD, and R. Stephen Smith, MD, RDMS, FACS

Background: Surgeon-performed ultrasound has become ubiquitous in the trauma suite. Initial reports suggest that sonography may be used for the detection of pneumothorax. The purpose of this study was to evaluate the efficacy of sonography to rule out the presence of a pneumothorax in the trauma population.

Methods: A prospective analysis of 328 consecutive trauma patients at an

American College of Surgeons-verified Level I trauma center was undertaken. Thoracic ultrasound was performed before chest radiography. The presence or absence of a "sliding-lung" sign or "comet-tail" artifact was recorded.

Results: Of 328 evaluations, there were 312 true-negatives, 12 true-positives, 1 false-negative, 1 false-positive, and 2 exclusions. Specificity, negative predictive

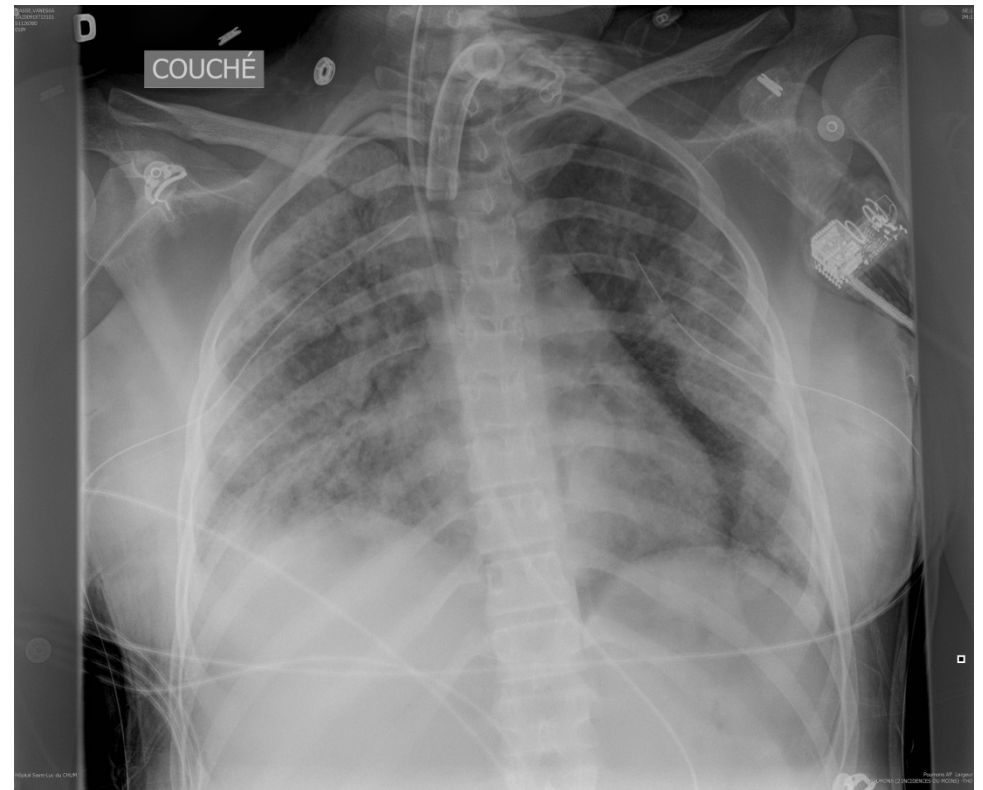
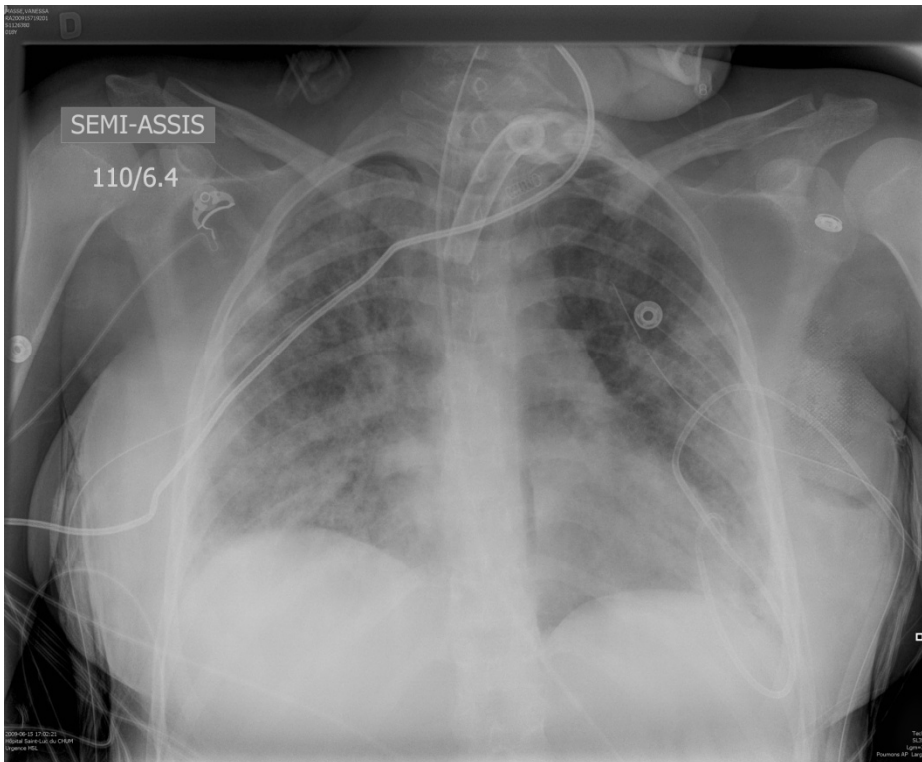
value, and accuracy were 99.7%, 99.7%, and 99.4%, respectively.

Conclusion: Ultrasound is a reliable modality for the diagnosis of pneumothorax in the injured patient. This modality may serve as an adjunct or precursor to routine chest radiography in the evaluation of injured patients.

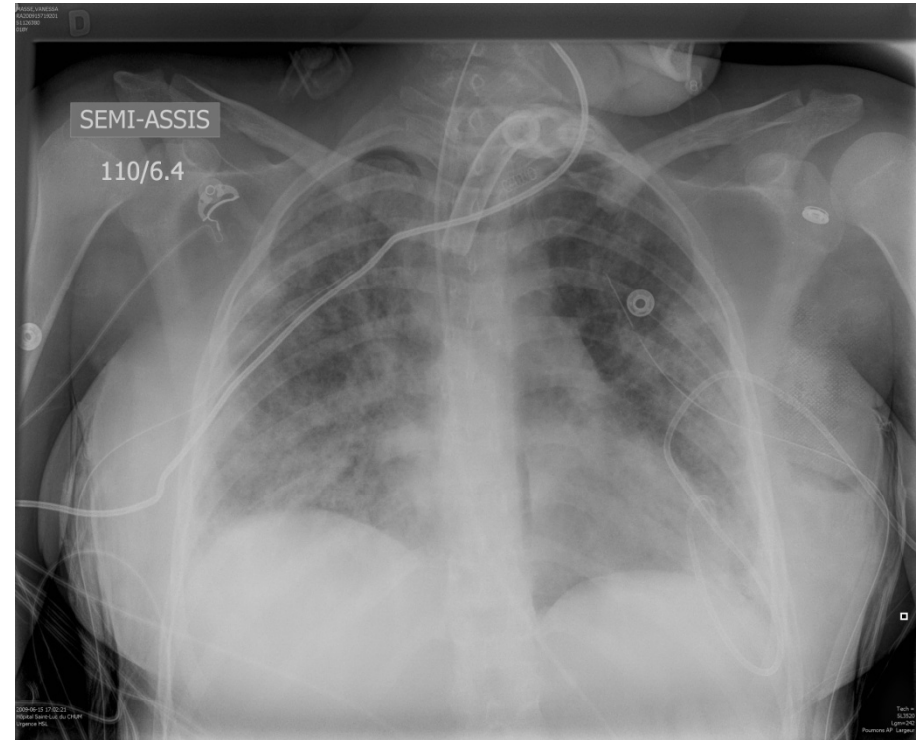
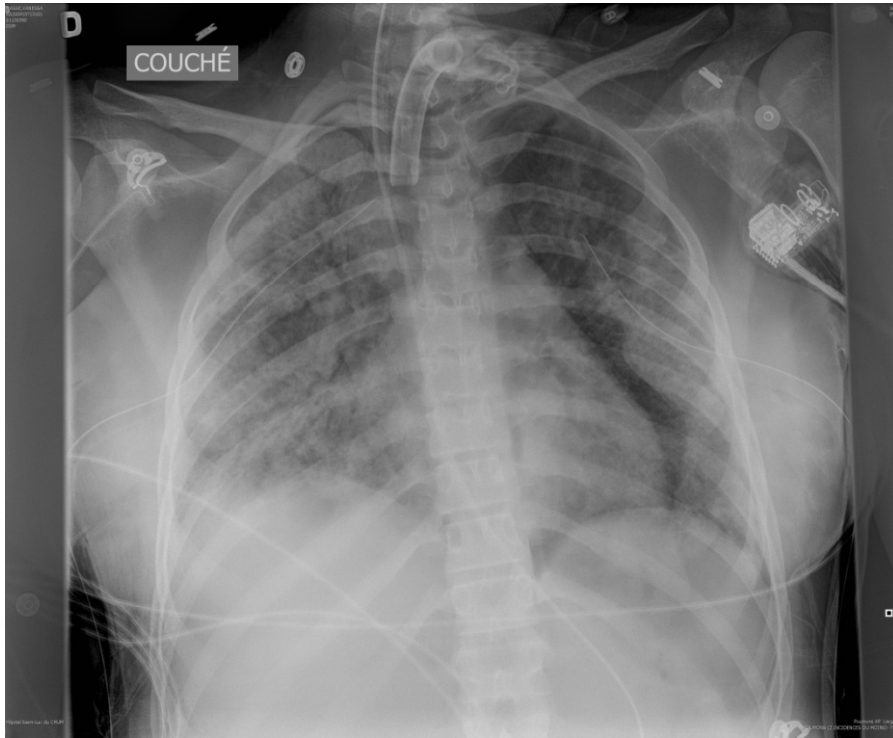
Key Words: Ultrasound, Trauma, Pneumothorax, Lung-sliding, Comet-tail.

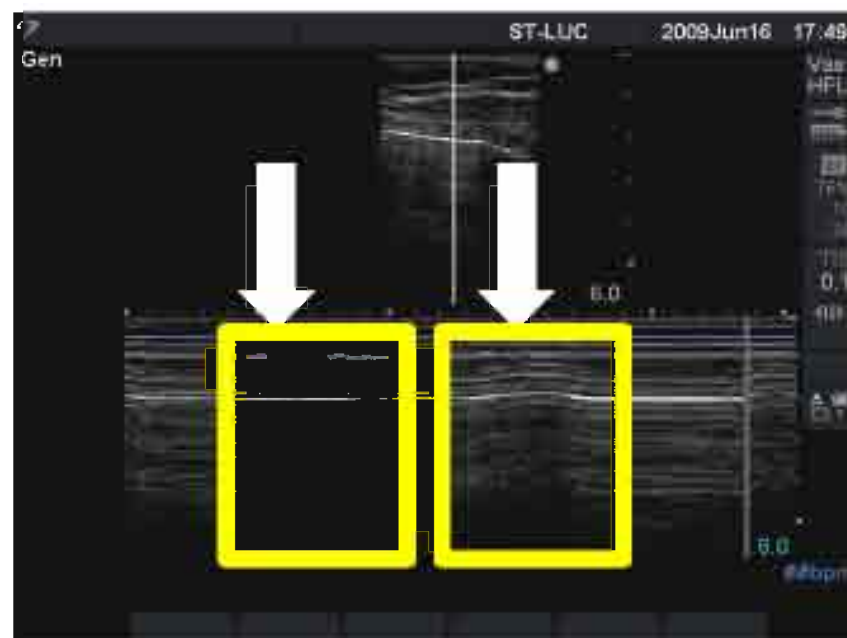
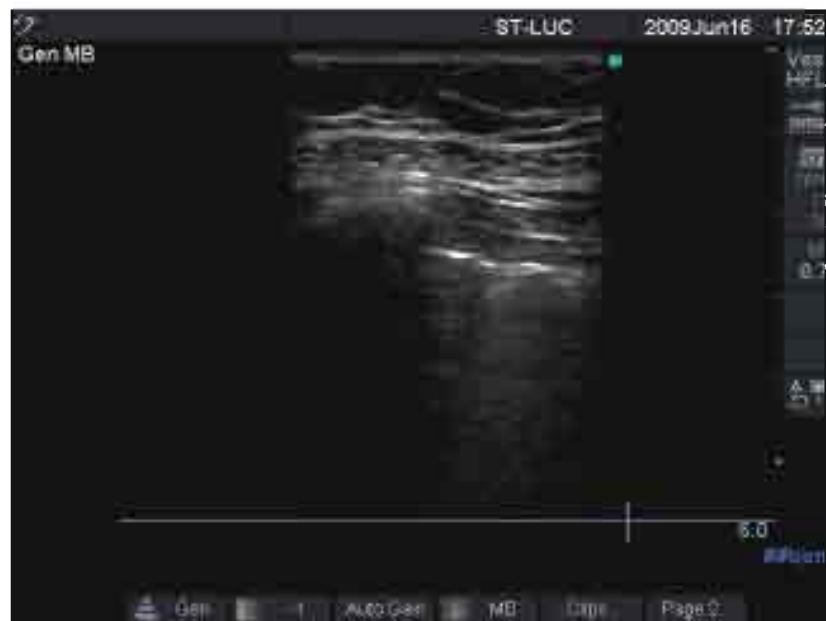
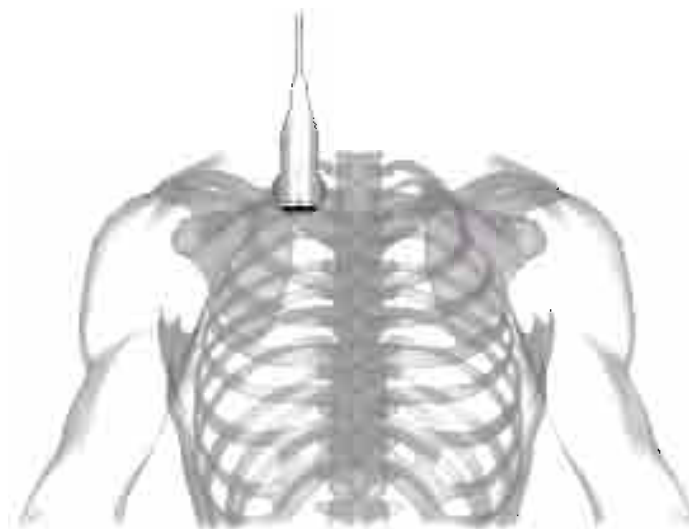
J Trauma. 2004;56:527-530.

26 yo ♀ severe desaturation post-op tracheostomie: after pigtail insertion

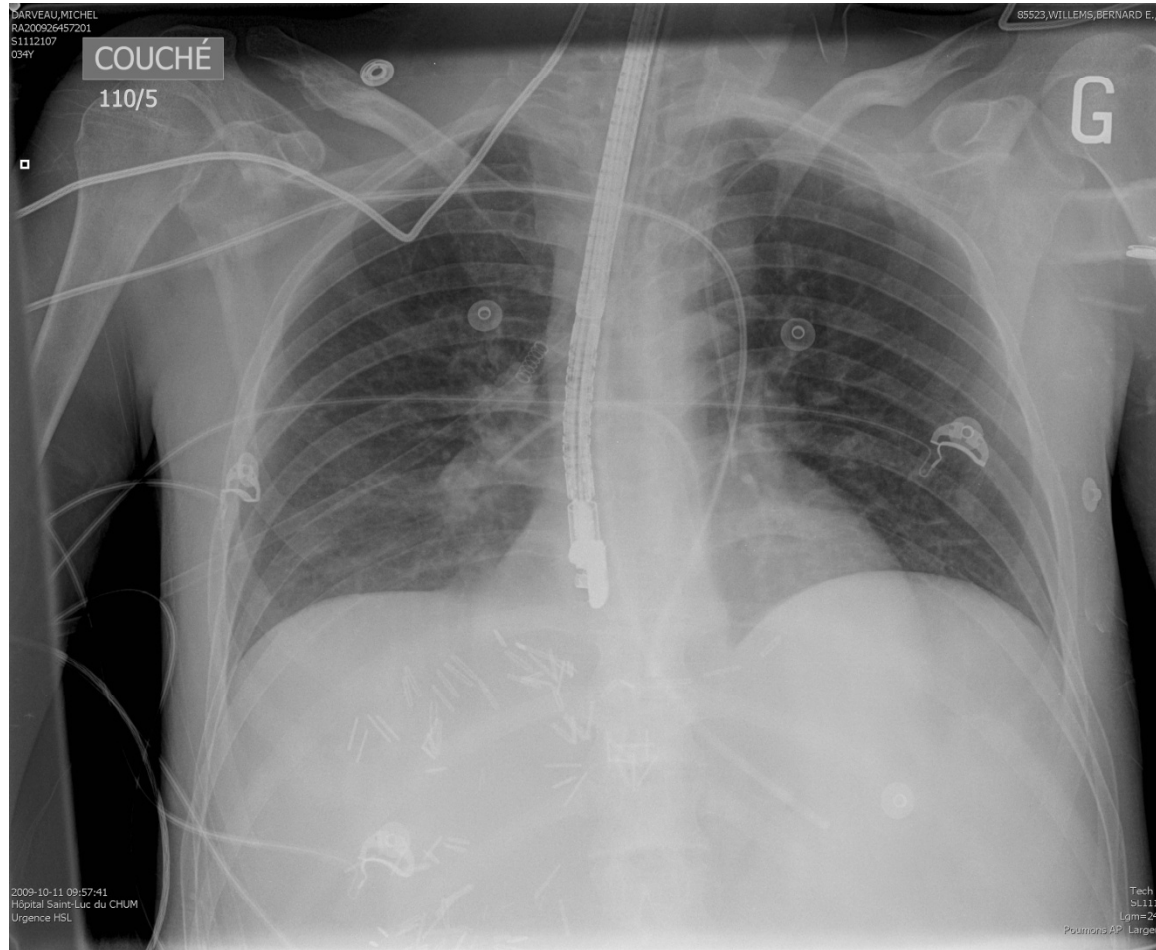


26 yo ♀ severe desaturation
post-op tracheostomie: ETCO₂
65 with a tidal volume of 150 ml

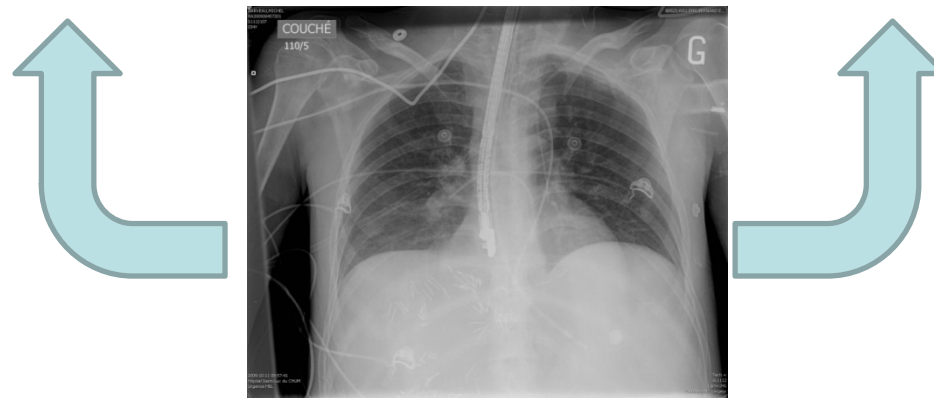
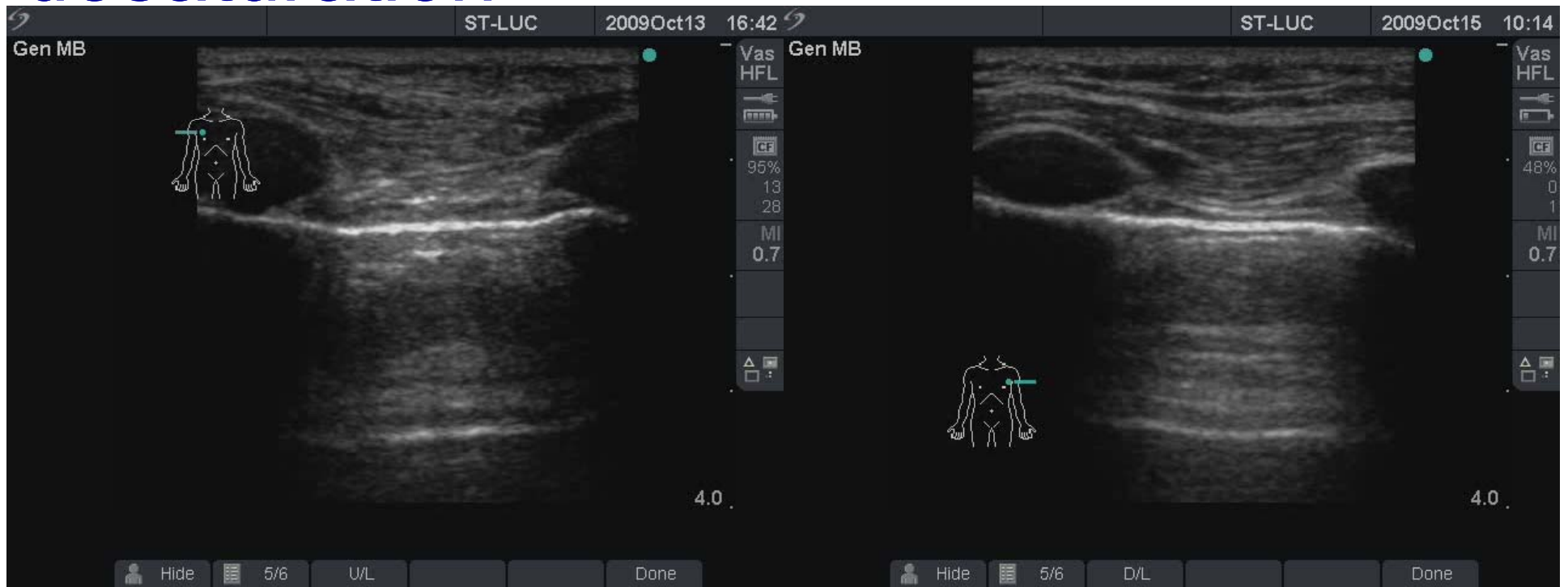




42 yo ♂ after liver transplantation: desaturation



42 yo ♂ after liver transplantation: desaturation



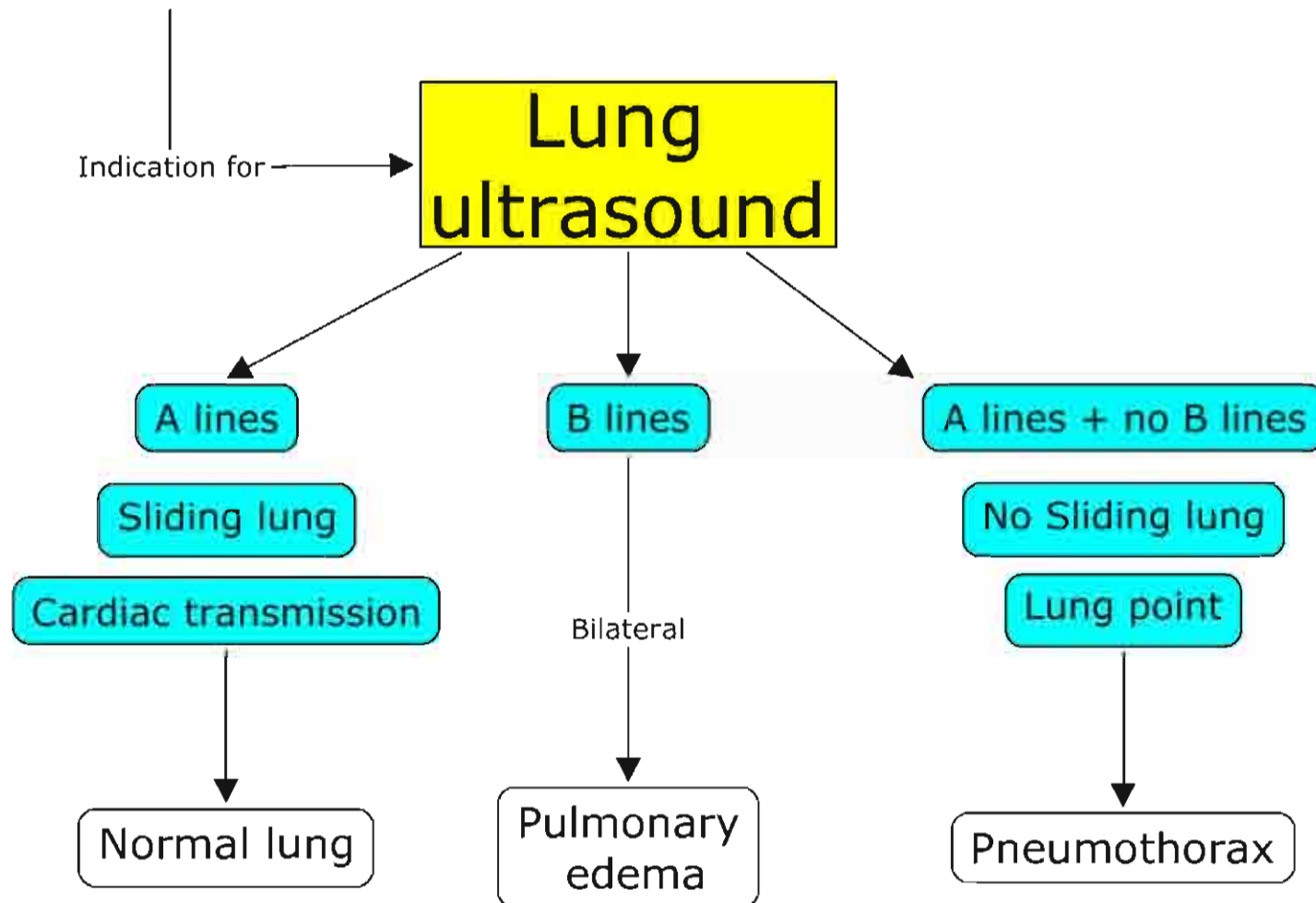
Right lung:



Lack of lung-sliding sign

- Pneumothorax
- Endobronchial intubation
- Atelectasis
- Severe ARDS
- Pleural adherence
- Chest tube
- Bullous emphysema
- Severe hyperinflation

Airway management
Breathing difficulty
Circulatory shock
Diagnosis: fever

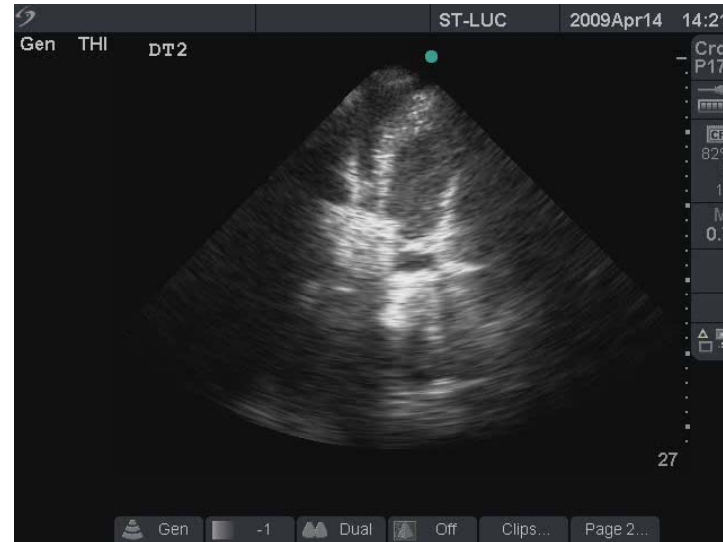


Diagnosis: pleural effusion

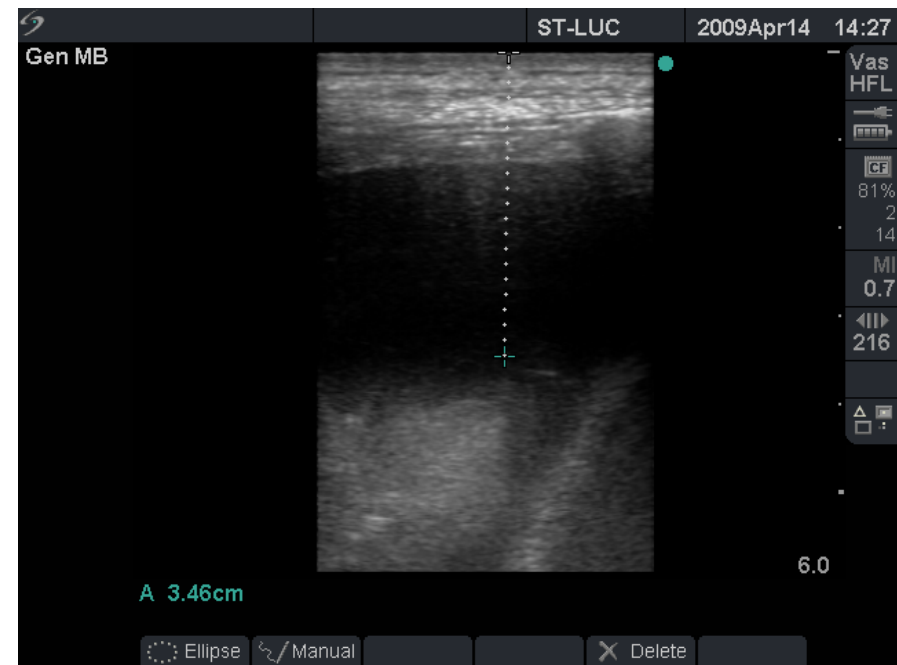
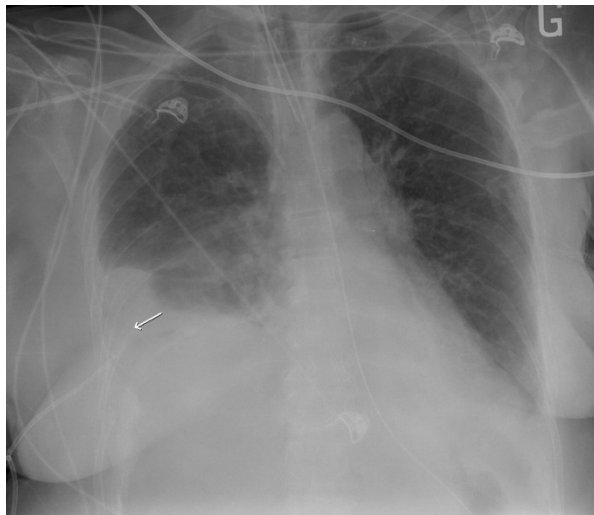
- Collection within the chest limited by the diaphragm and the pleura
- The dimension changes with respiration
- Associated with lung atelectasis or consolidation
- Types:
 - Simple: anechoic (black) (transudate or exudate) = pigtail
 - Complex: hyperechogenic (exsudate) = chest tube



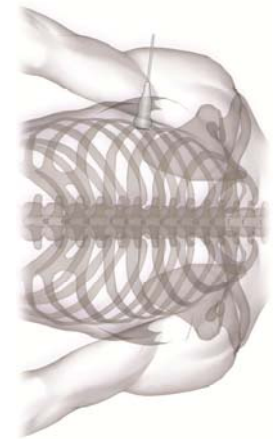
Left side: phased array transducer



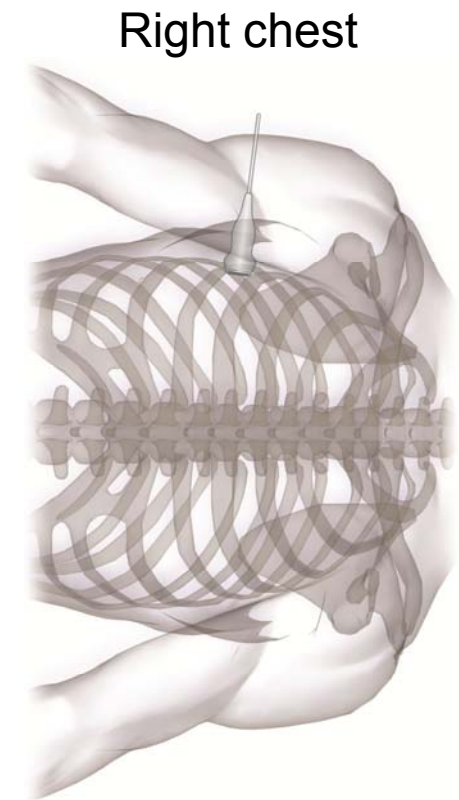
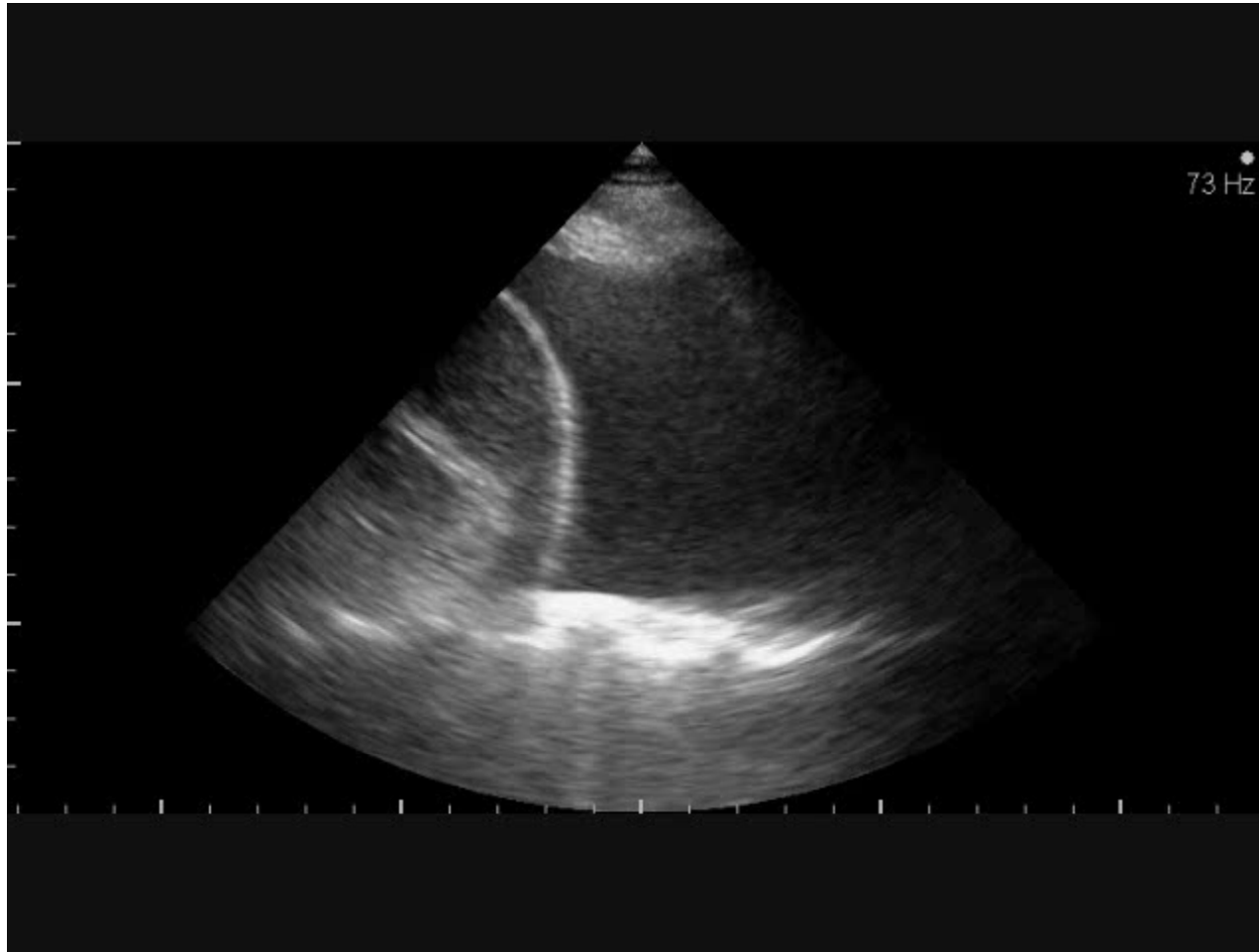
Right side: linear array transducer



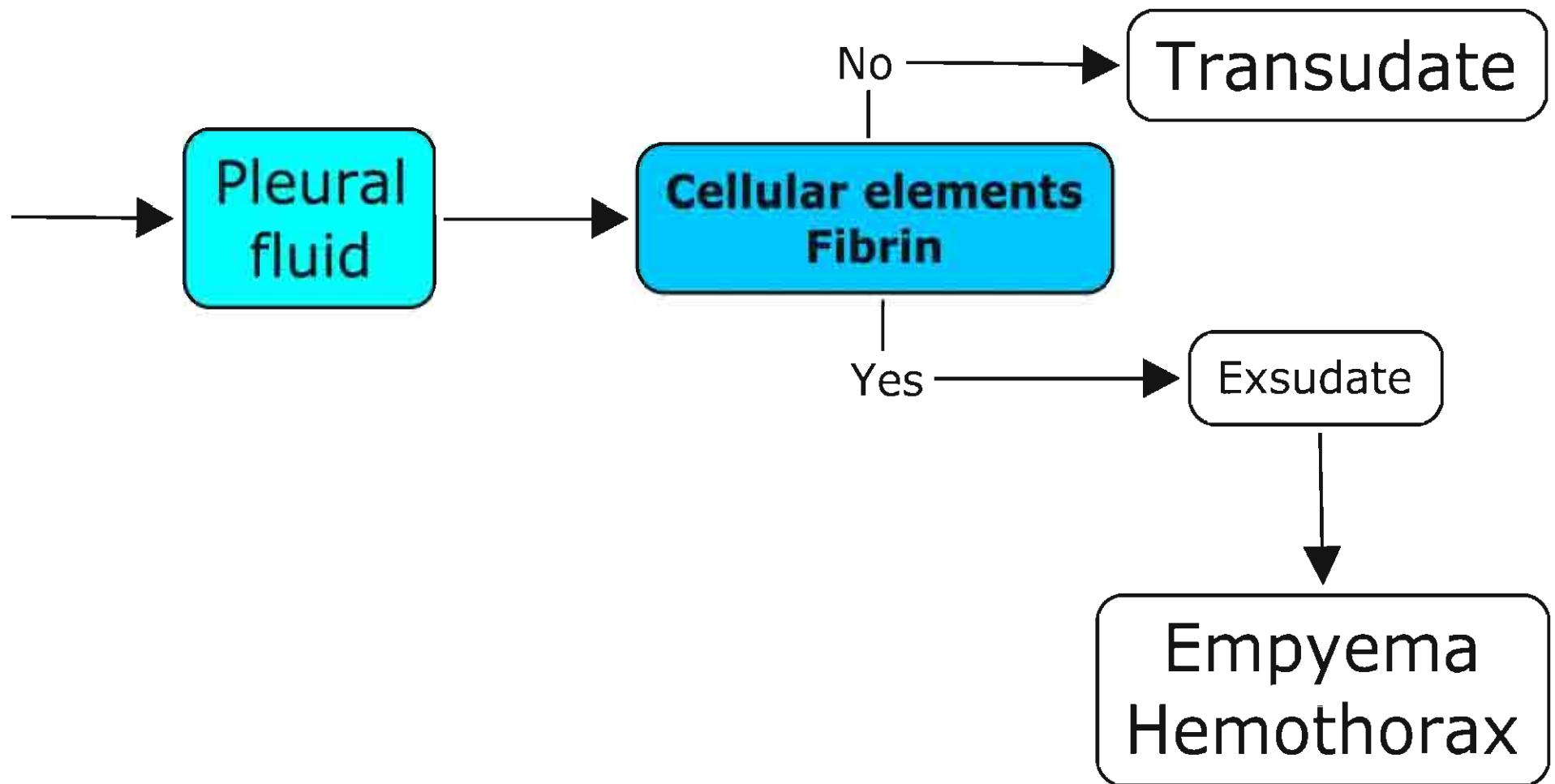
Pleural effusion



Pleural fluid aspect



Courtesy of Philippe Rola



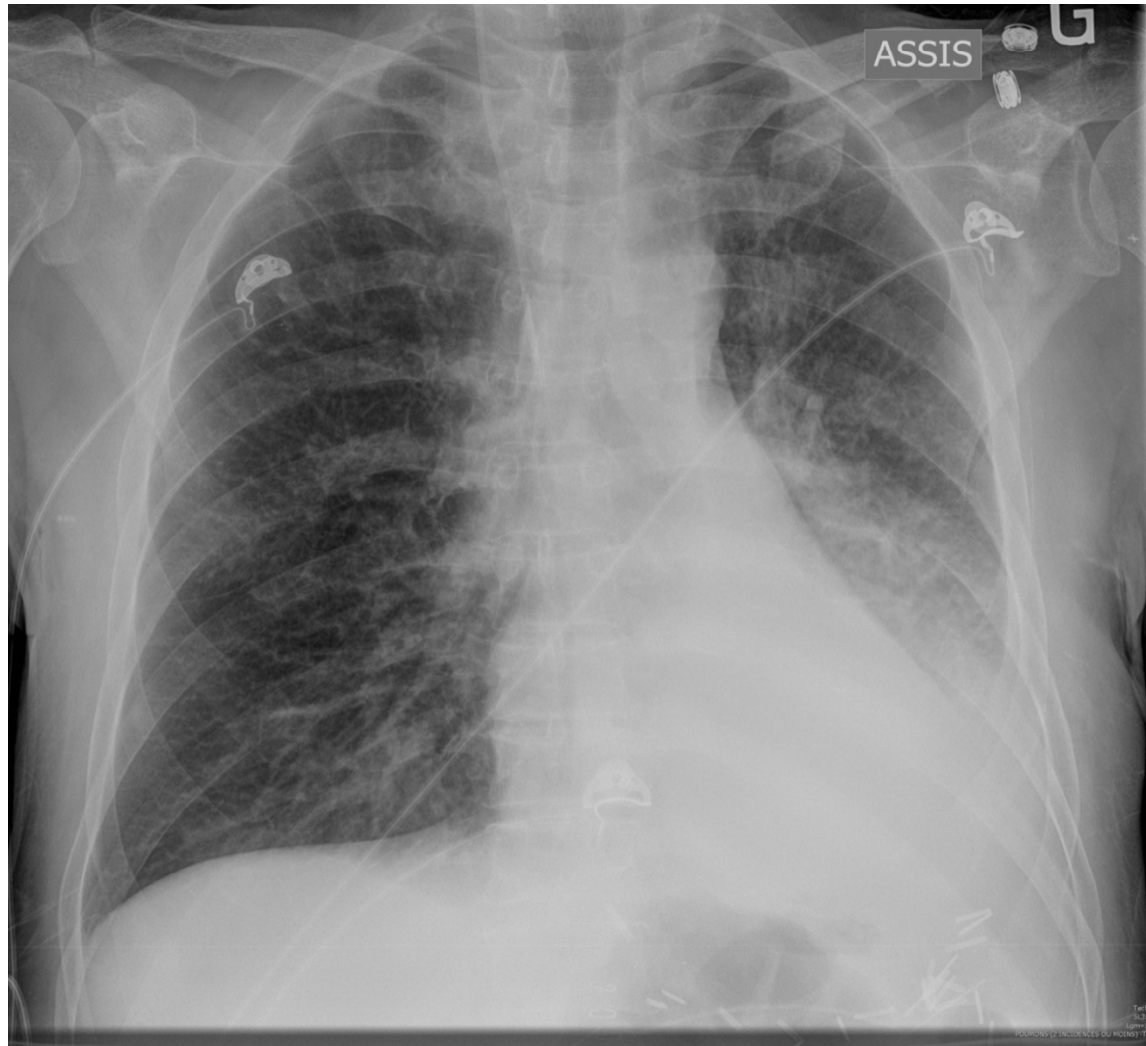
Diagnosis: atelectasis and pneumonia

Lung region of tissular pattern whose dimension remain unchanged with respiration

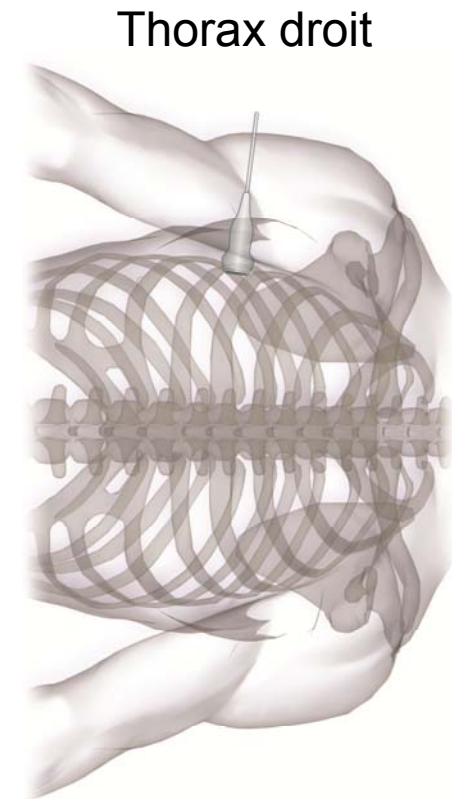
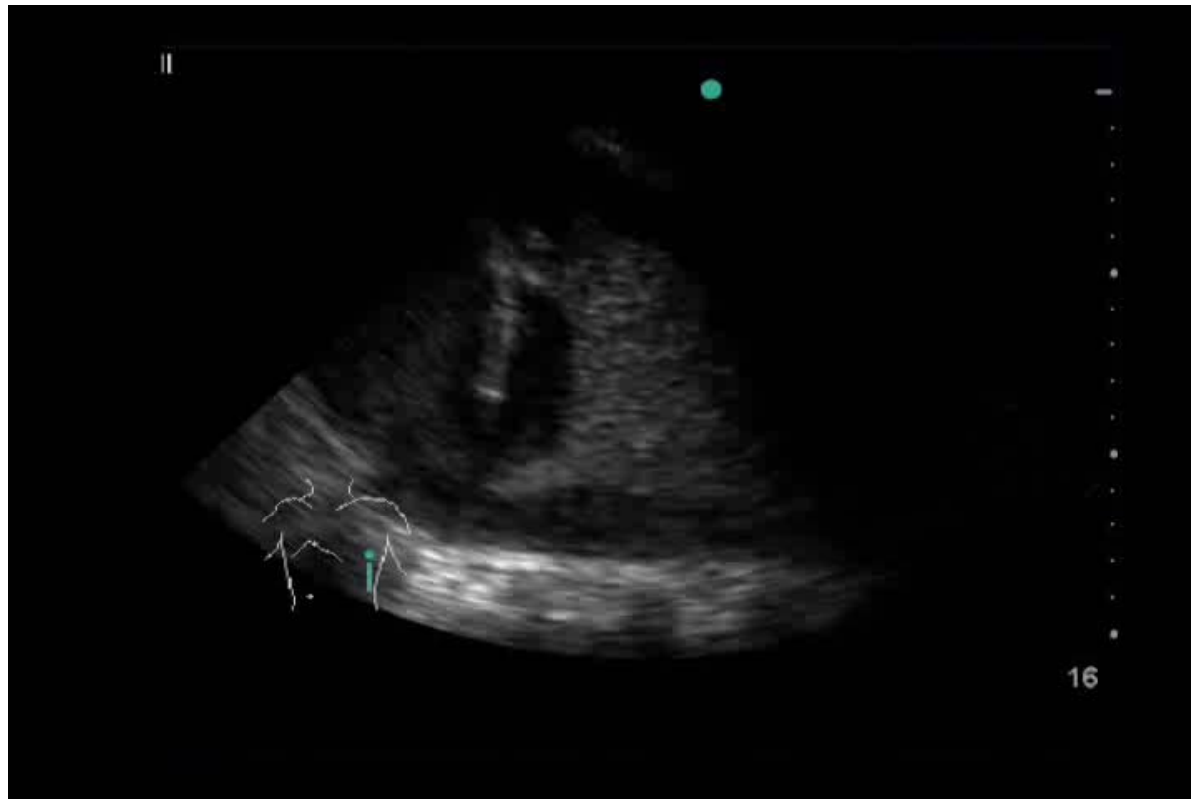
Homogeneous: passive atelectasis

Heterogeneous with air bronchogram:
suggestive of pneumonia

Atelectasis or pneumonia?

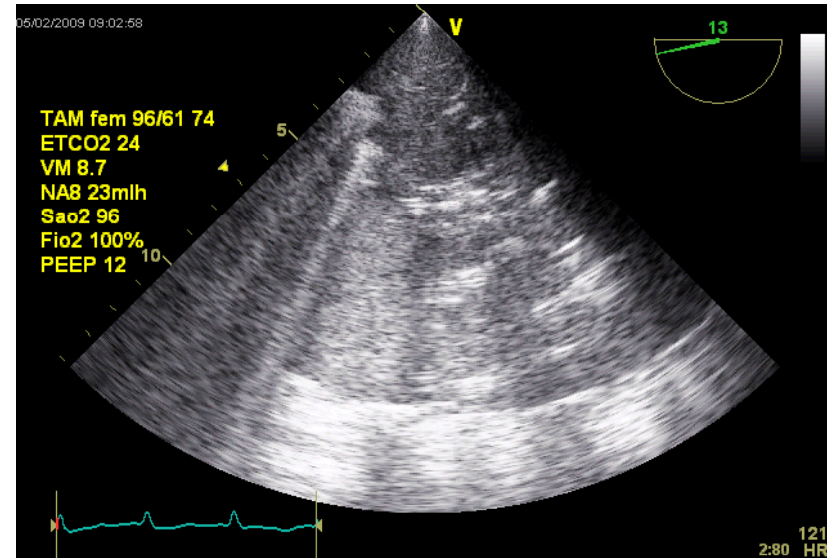
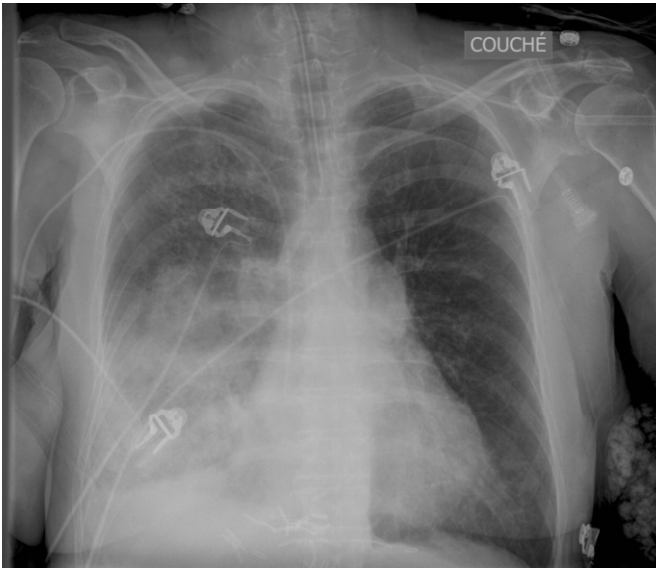


Atelectasis or pneumonia?

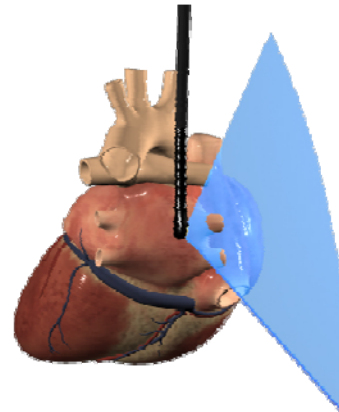
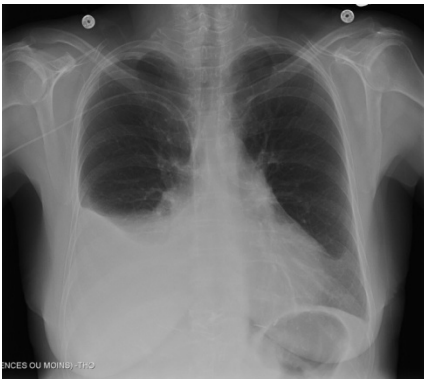


58 yo ♀ hemodynamically unstable after liver transplantation

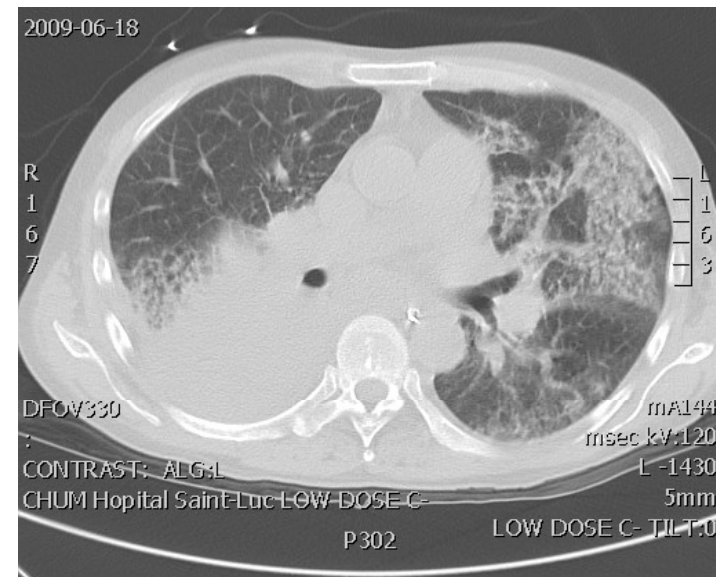
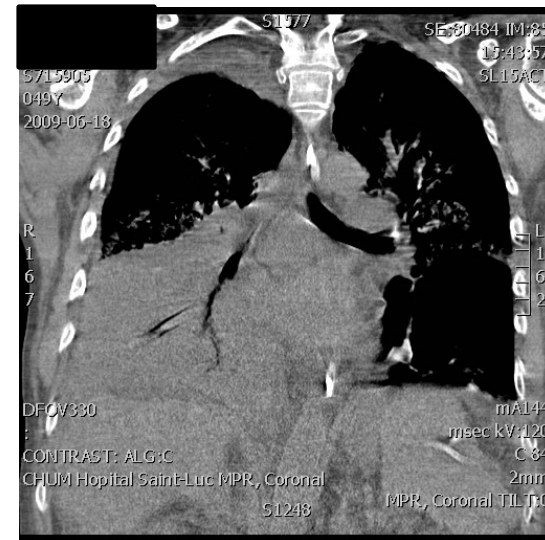
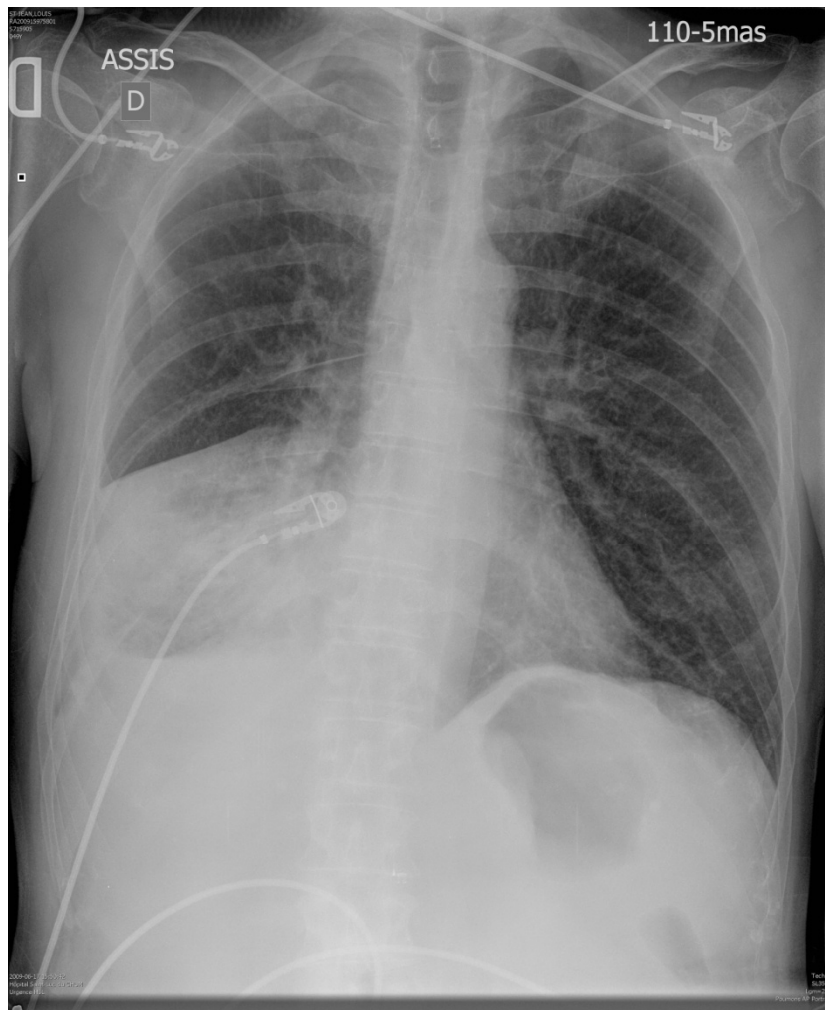
During



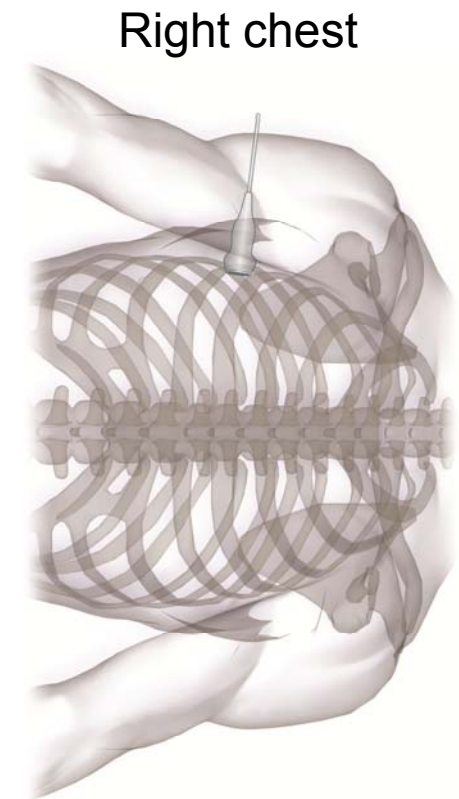
Before

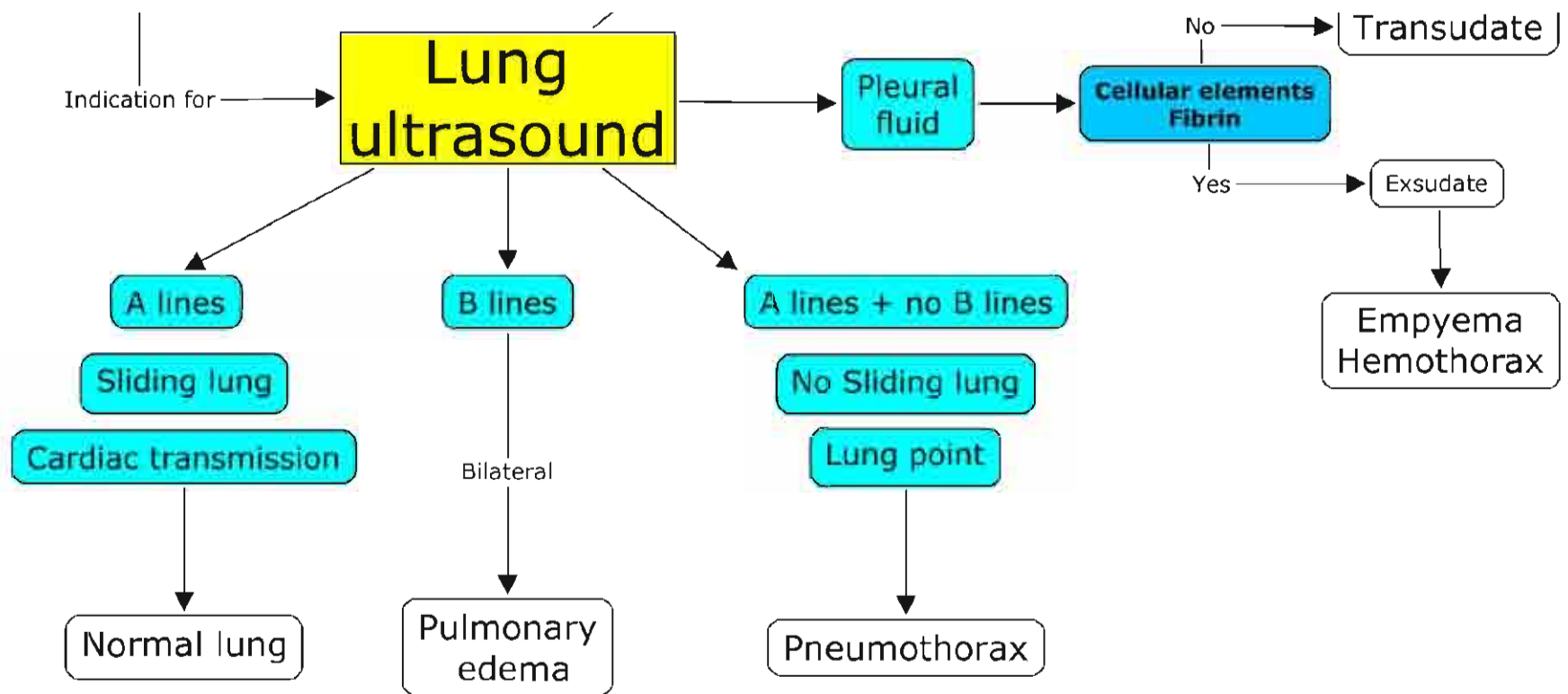
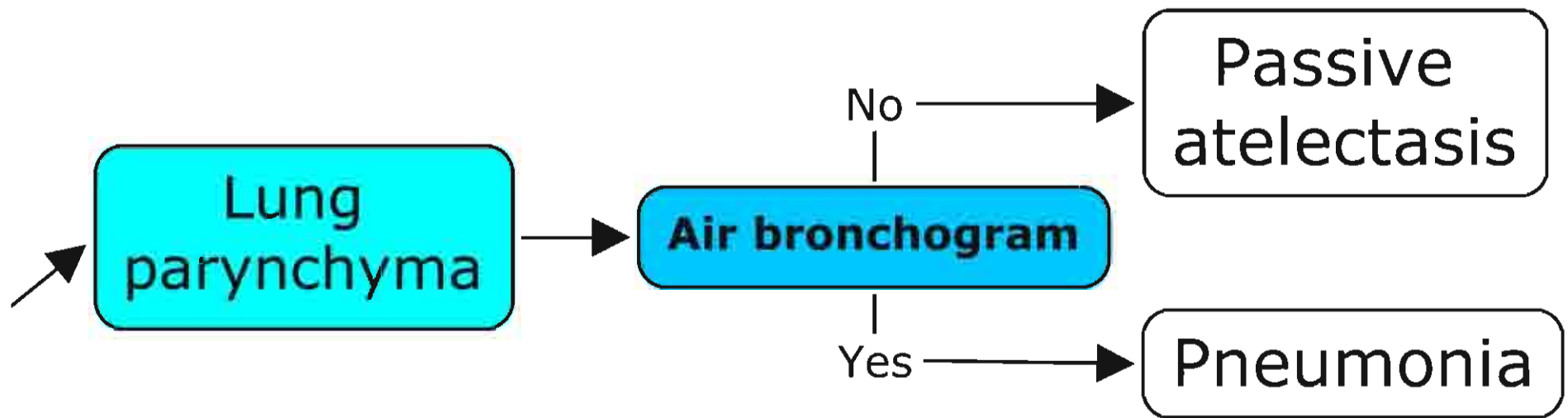


49 yo ♂ with fever in the ER



49 yo ♂ with sepsis in the ER:
positive blood culture pneumococcus pneumonia

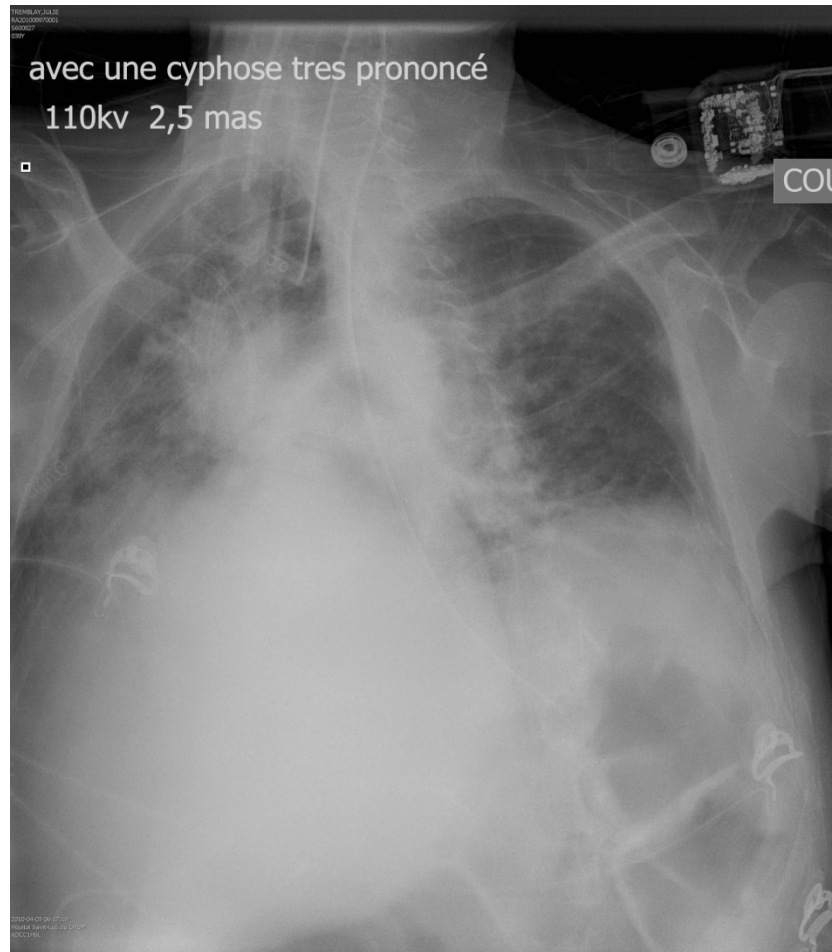




43 yo acute SOB on the ward: pulmonary emboli?



43 yo ♀ acute SOB on the ward



Limitations of lung ultrasound

- Requires ultrasound equipment
- Need a window to the chest
 - ✓ Dressings
 - ✓ Very obese patient
 - ✓ Subcutaneous emphysema
 - ✓ Miss central thoracic structures
- Operator dependent
- Training



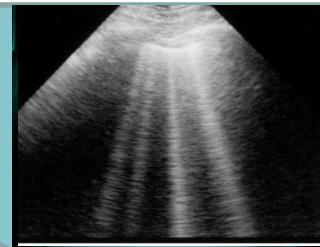
Content of the lung

Pleural effusion



Sen/Spe: 97% 94%

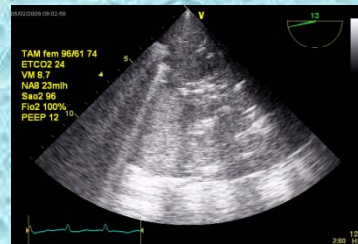
Interstitial edema



Air

Sen/Spe: 100% 100%

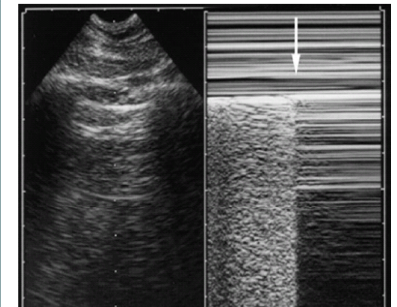
Pneumonia



Sen/Spe: 90% 98%

Liquid

Pneumothorax



Sen/Spe: 79% 100%

In summary

- Lung ultrasound is actually used by several specialties worldwide
- It is indicated in situations relevant to the care of the patient under or after anesthesia
- Critical Care Ultrasonography will be considered part of the training curriculum of every anesthesiologist