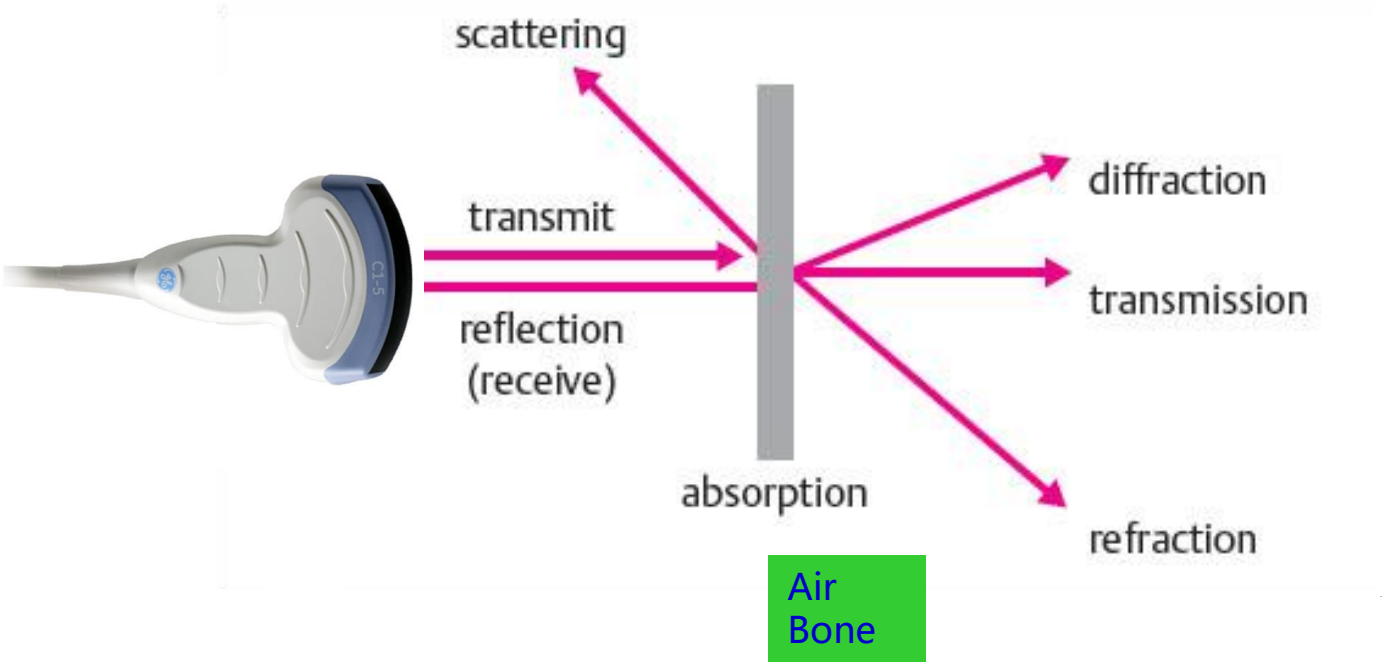
대한심장혈관흉부외과학회
The Korean Society for Thoracic & Cardiovascular Surgery
The 38th KTCVS
Spring Meeting
2024 SEOUL
AAPCHS
The 4th AAPCHS
May 31st - June 1st
Seoul Dragon City Hotel

Lung and Pleura...

Hyun Joo Lee, M.D., Ph.D.
Department of Thoracic and Cardiovascular Surgery
Seoul National University Hospital

- **Nothing to disclose**

Lung Ultrasound



https://radiologykey.com

Lung Ultrasound

Qualitative Approach : diagnosis


Intensive Care Med (2012) 38:577–591
DOI 10.1007/s00134-012-2513-4

CONFERENCE REPORTS AND EXPERT PANEL

Giovanni Volpicelli
Mahmoud Elbarbary
Michael Blaivas
Daniel A. Lichtenstein
Gebhard Mathis
Andrew W. Kirkpatrick

International evidence-based recommendations for point-of-care lung ultrasound

Reflection

Clinical application

Comet tail artifact

B-lines

Interstitial syndrome
Subpleural
Consolidations

1st International Consensus

1961 Duun and fry

1967 Joyner et al
1067 Miller et al

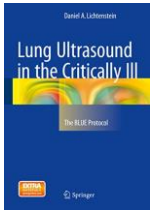
1982 Ziskin et al
1983 Thickman
1985 Avruch and Cooperberg

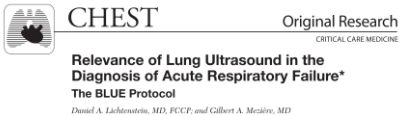
1997
Lichtenstein
alveolar-interstitial syndrome (CT)

1993
Mathis and Dirschmid
(pathology)

2004 Jambrik EVLW
2006 Picano CPE
2008 Copetti ARDS

2008
Lichtenstein
Blue Protocol




CHEST Original Research
CRITICAL CARE MEDICINE

Relevance of Lung Ultrasound in the Diagnosis of Acute Respiratory Failure*

The BLUE Protocol

Daniel A. Lichtenstein, MD, FCCP; and Gilbert A. Mezière, MD

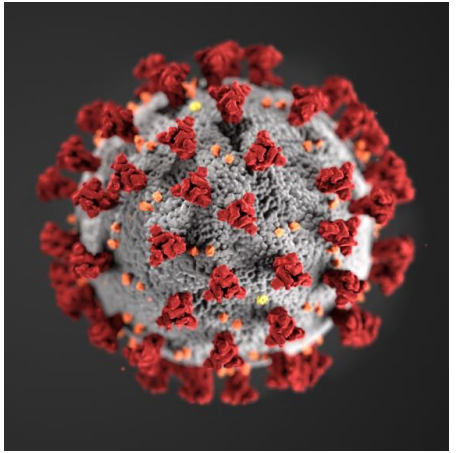
Ultrasound in Med & Biol. 2022;48:2398-2416
J Ultrasound Med 2023;42:309-344

COVID-19

ORIGINAL ARTICLE Open Access

Monitoring of pulmonary involvement in critically ill COVID-19 patients - should lung ultrasound be preferred over CT?

Arthur W. E. Lieveld[1,2*†], Micah L. A. Heldeweg[2,5†], Jasper Schouwenburg[2], Lars Veldhuis[2], Mark E. Haaksma[2,5], Rutger M. van Haaften[3], Berend P. Teunissen[3], Jasper M. Smit[2,5], Jos Twisk[4], Leo Heunks[2], Prabath W. B. Nanayakkara[1] and Pieter Roel Tuinman[2,5]



Proposal for International Standardization of the Use of Lung Ultrasound for Patients With COVID-19

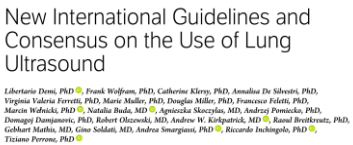
A Simple, Quantitative, Reproducible Method

Gino Soldati, MD, Andrea Smargiassi, MD, PhD, Riccardo Inchingolo, MD, Danilo Buonsenso, MD, Tiziano Perrone, MD, PhD, Domenica Federica Briganti, MD, Stefano Perlini, MD, PhD, Elena Torri, MD, Alberto Mariani, MD, Elisa Eleonora Mossolani, MD, Francesco Tursi, MD, Federico Mento, MSc, Libertario Demi, PhD

Lung Ultrasound

Qualitative Approach

Quantitative Approach: monitoring



Reflection

Clinical application

Comet tail artifact

B-lines

Interstitial syndrome
Subpleural
Consolidations

1st International Consensus

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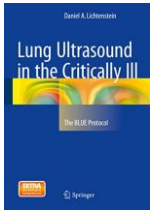
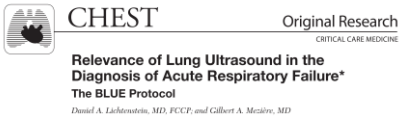
Blue Protocol





Ultrasound in Med & Biol. 2022;48:2398-2416
J Ultrasound Med 2023;42:309-344

New International Guidelines and Consensus on the Use of Lung Ultrasound

Libertario Demi, PhD, Frank Wolfram, PhD, Catherine Klersy, PhD, Annalisa De Silvestri, PhD, Virginia Valeria Ferretti, PhD, Marie Muller, PhD, Douglas Miller, PhD, Francesco Feletti, PhD, Marcin Wełnicki, PhD, Natalia Buda, MD, Agnieszka Skoczylas, MD, Andrzej Pomiecko, PhD, Domagoj Damjanovic, PhD, Robert Olszewski, MD, Andrew W. Kirkpatrick, MD, Raoul Breitkreutz, PhD Gebhart Mathis, MD, Gino Soldati, MD, Andrea Smargiassi, PhD, Riccardo Inchingolo, PhD, Tiziano Perrone, PhD

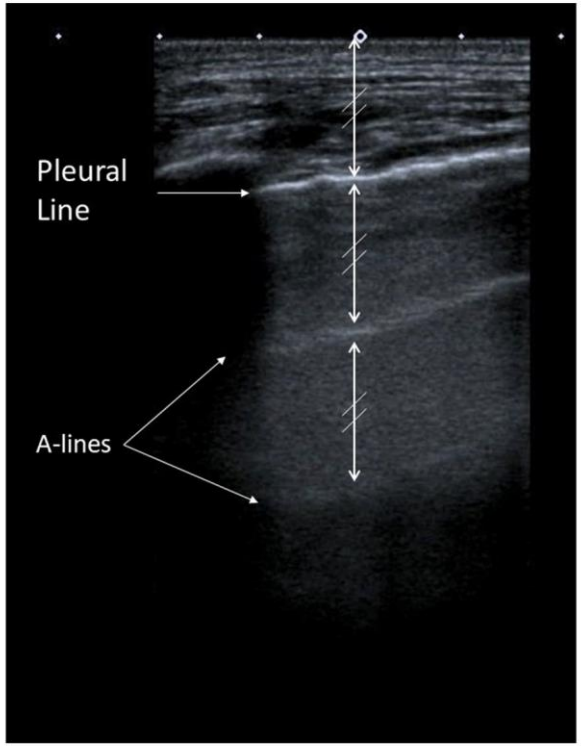
- Technical (5)
- Safety (1)
- Clinical (11)
- Educational (3)

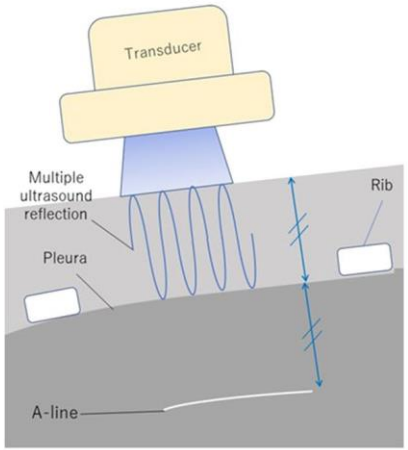
Table 1. Summarization of Statements and Guidelines

Statement ID	Statement Classification	Statement Text
1	Technical	As it is already happening in other areas of medical imaging, artificial intelligence (AI) is now being applied to the analysis of LUS data. Critical and well-detailed studies are fundamental to prevent over expectations and misuse of this technology.
2	Technical	Before new technologies will be mature, LUS will continue to be performed with standard ultrasound (US) imaging. In order to improve its reproducibility, standardization of imaging protocols is essential.
3	Technical	In the current definition, B-line artifacts represent a wide variety of patterns. It is crucial to understand the physical origin of their genesis and to characterize the signals responsible for their visualization. This is a fundamental step toward the development of quantitative US modalities dedicated to the diagnosis and monitoring of lung diseases
4	Technical	It is indispensable to find a consensus on objective parameters for the evaluation of regularity/ irregularity/thickening of the pleural line and the distinction of micro and macro subpleural consolidations, both for dimensional criteria and for US aspects.
5	Technical	It is necessary to improve the comprehension of the qualitative and quantitative characteristics of the artifacts currently called B-lines in relation to the physiological and pathophysiological changes of histology of the lung.
6	Safety	In animal models, there is evidence that lung ultrasound (LUS) in the diagnostic regime can induce pulmonary capillary hemorrhage. It is therefore required to investigate the need for specific safety limits for US technologies when applied to the monitoring and diagnosis of lung diseases
7	Clinical	There is a need for high quality studies (randomized, prospective) to achieve acceptance for the diagnostic value of LUS as performed for other screening tests (breast, heart).
8	Clinical	There should be evidence and/or consensus for the terminology used to describe artifacts and signs in LUS and for the definition of the extent of the LUS exam.
9	Clinical	It seems reasonable to perform repeated LUS scans to assess the severity of pulmonary congestion, with one and the same probe and protocol each time. Generally, repeated LUS scans can be used for the assessment of the severity of a condition and its progression over time. Always, use one and the same probe and protocol each time.
10	Clinical	LUS should be performed on the largest possible area of the chest that is available during LUS examination (the limitation of the examination area should be justified by the patient's clinical condition).
11	Clinical	LUS has high accuracy in recognition of subpleural consolidation. Subpleural consolidations best known in LUS are: inflammatory lesions, atelectasis, infarction, and metastatic subpleural lesions.
12	Clinical	LUS is feasible and useful in general/family medicine.
13	Clinical	LUS is feasible and useful in prehospital emergency medicine.
14	Clinical	LUS should be used by clinicians as a "point of care" examination in case of patient with dyspnea, chest pain and any chest symptoms.
15	Clinical	The technique of the examination depends on the clinical situation of the patient.
16	Clinical	The functional assessment of the diaphragm may integrate the data of lung alteration to address or refine the differential diagnosis of respiratory failure in intensive care units (ICUs).
17	Clinical	The most common sonographic features in case of pneumonia are: consolidation (with irregular marginal contour, air bronchogram, the air trapping sign), vertical artifacts (B-lines), and the presence of pleural effusion.
18	Educational	It is strongly recommended to acquire adequate training in LUS before its implementation in the diagnostic process.
19	Educational	It is recommended to teach the basis of LUS as part of the students' curriculum.
20	Educational	Remote mentoring of US naive, but motivated and willing first responders has been shown to be a potentially accurate method of generating diagnostic quality ultrasound images that can then be interpreted by remote ultrasound experts.

- Technical Aspects (Machine Setting and Probes)
- Locations
- Qualitative Finding
- Quantitative Finding
- Others

Lung Ultrasound

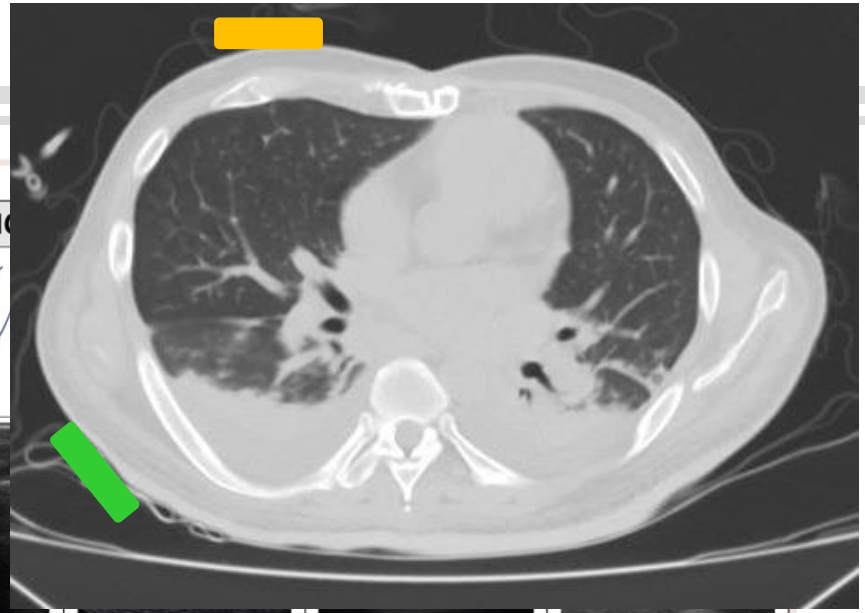




- Using Artifact between air-tissue interface
- Focus: parietal pleura
- Artifact-erasing effect: off

J Echocardiogr 2021;19:195-204
Adv Respir Med 2023;91:203-223

Probes



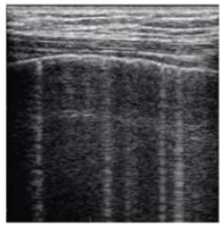
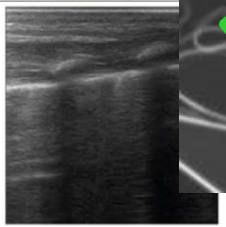
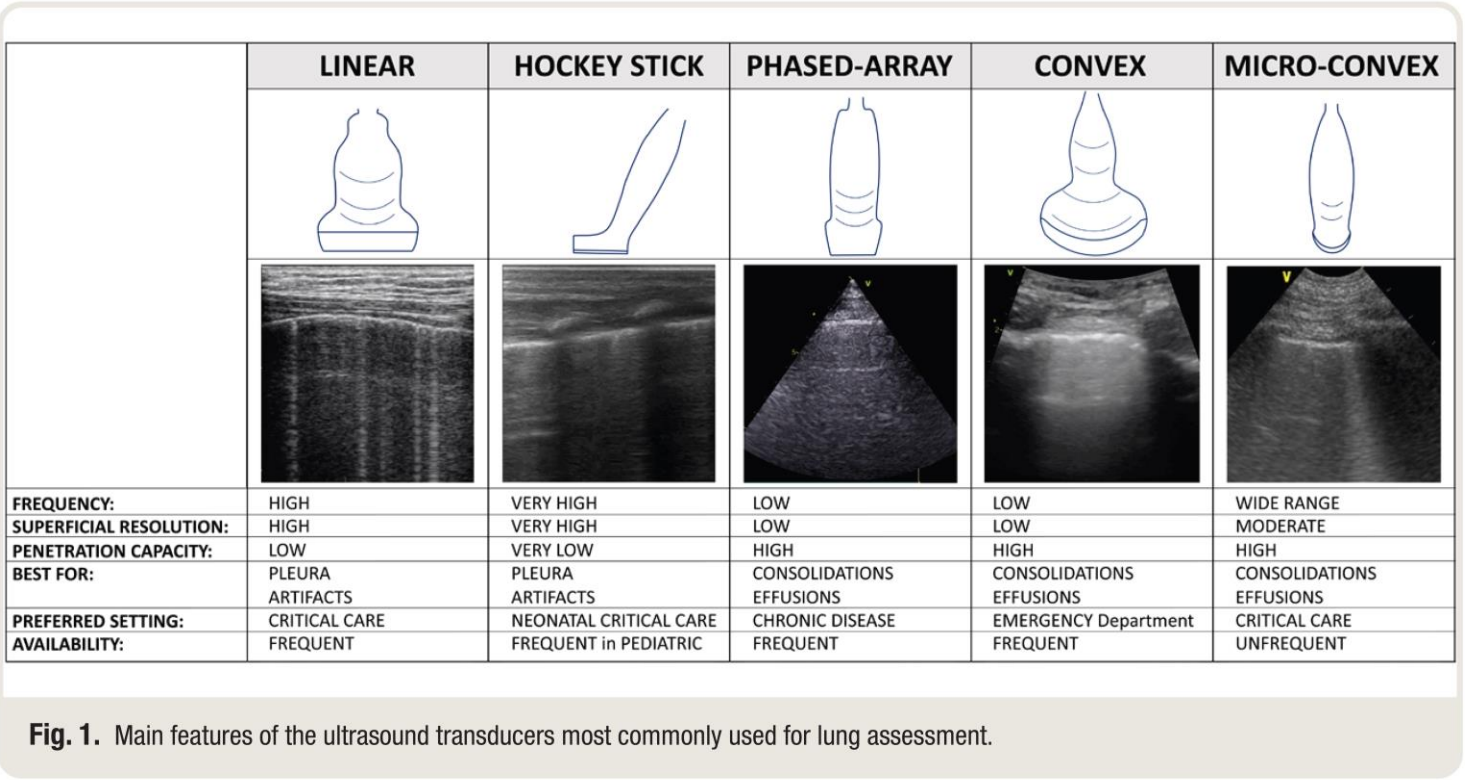
	LINEAR	HOCKEY STI			
					
FREQUENCY:	HIGH	VERY HIGH	LOW	LOW	WIDE RANGE
SUPERFICIAL RESOLUTION:	HIGH	VERY HIGH	LOW	LOW	MODERATE
PENETRATION CAPACITY:	LOW	VERY LOW	HIGH	HIGH	HIGH
BEST FOR:	PLEURA ARTIFACTS	PLEURA ARTIFACTS	CONSOLIDATIONS EFFUSIONS	CONSOLIDATIONS EFFUSIONS	CONSOLIDATIONS EFFUSIONS
PREFERRED SETTING:	CRITICAL CARE	NEONATAL CRITICAL CARE	CHRONIC DISEASE	EMERGENCY Department	CRITICAL CARE
AVAILABILITY:	FREQUENT	FREQUENT in PEDIATRIC	FREQUENT	FREQUENT	UNFREQUENT

Fig. 1. Main features of the ultrasound transducers most commonly used for lung assessment.

Anesthesiology 2021;134:949-65

Probes



	LINEAR	HOCKEY STICK	PHASED-ARRAY	CONVEX	MICRO-CONVEX
FREQUENCY:	HIGH	VERY HIGH	LOW	LOW	WIDE RANGE
SUPERFICIAL RESOLUTION:	HIGH	VERY HIGH	LOW	LOW	MODERATE
PENETRATION CAPACITY:	LOW	VERY LOW	HIGH	HIGH	HIGH
BEST FOR:	PLEURA ARTIFACTS	PLEURA ARTIFACTS	CONSOLIDATIONS EFFUSIONS	CONSOLIDATIONS EFFUSIONS	CONSOLIDATIONS EFFUSIONS
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Fig. 1. Main features of the ultrasound transducers most commonly used for lung assessment.

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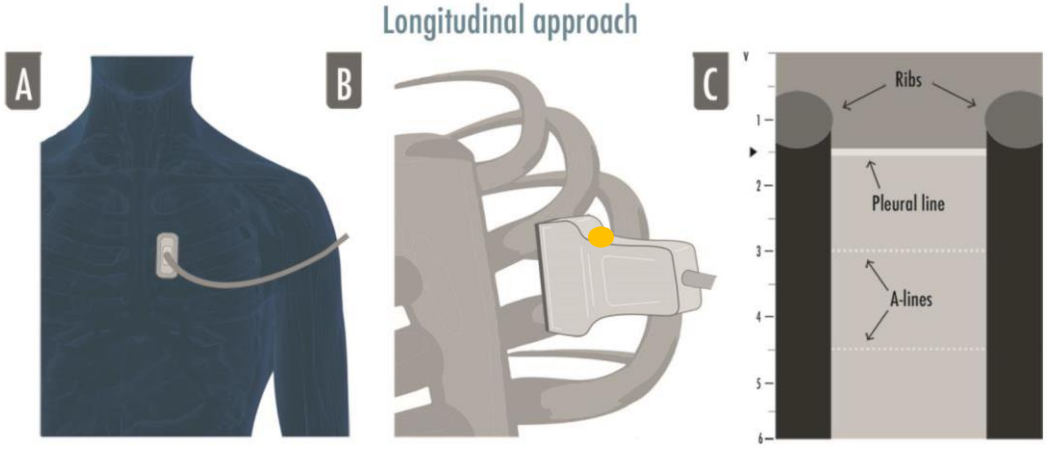
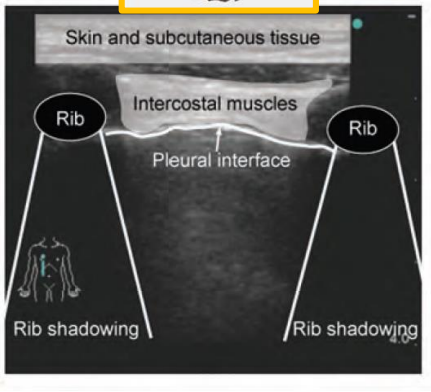
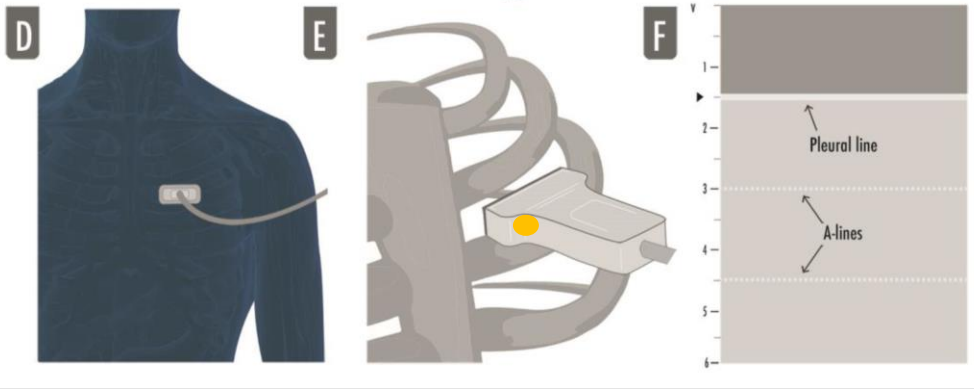
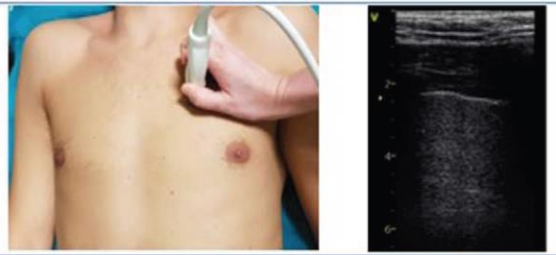






Adv Respir Med 2023;91:203-223

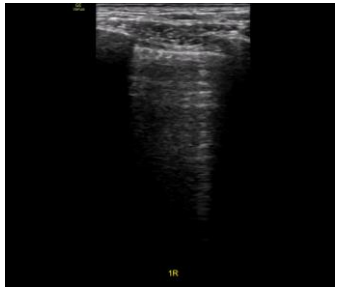
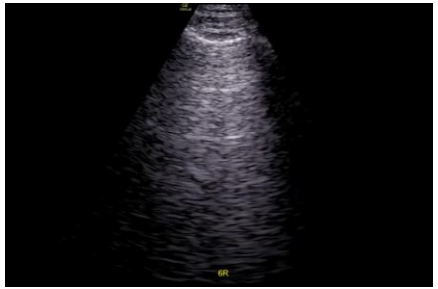
Longitudinal / Transversal Scan

LONGITUDINAL SCAN	TRANSVERSAL SCAN
Aligned with cranio-caudal axis	Aligned with intercostal space
	
PROs	**PROs**
- Easy to obtain: ideal for beginners - Clear identification of the pleural line: ideal in doubtful cases (for example: subcutaneous emphysema)	- Visualization of wider pleura - More constant visualized pleural length (between and within patients) - Visualization of more artefacts
CONs	**CONs**
- Visualization of shorter pleura - High pleural length variance - Visualization of fewer artefacts	- More technically challenging: not for beginners - In case of doubtful identification of the pleura: start with longitudinal and then turn the probe

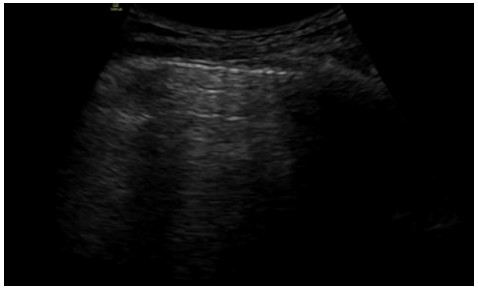
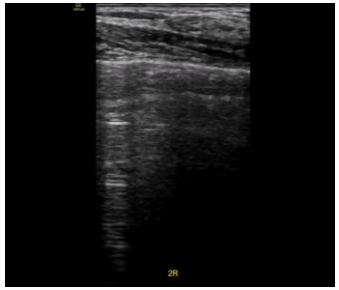
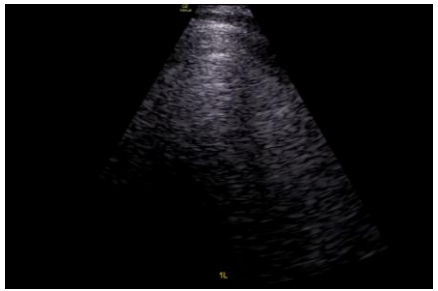
Anesthesiology 2021;134:949-65







1R

6R

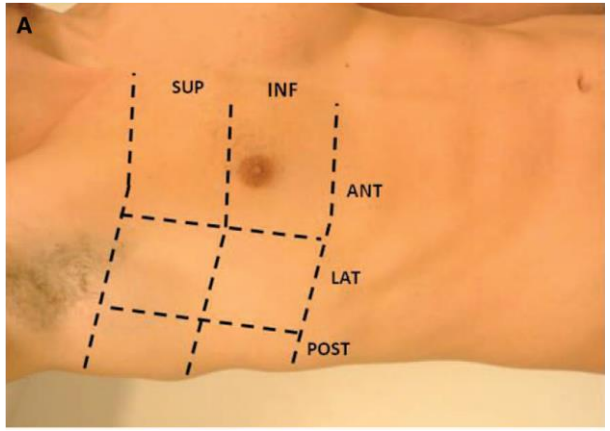
4R

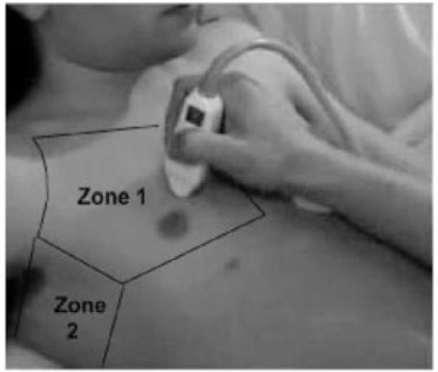



2R

1L

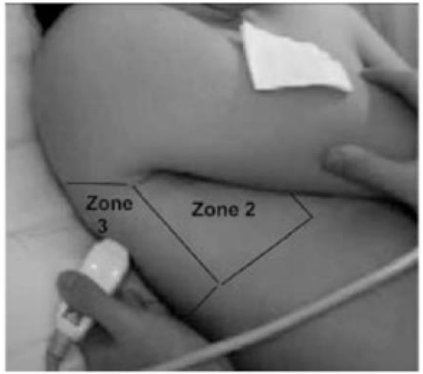
5R

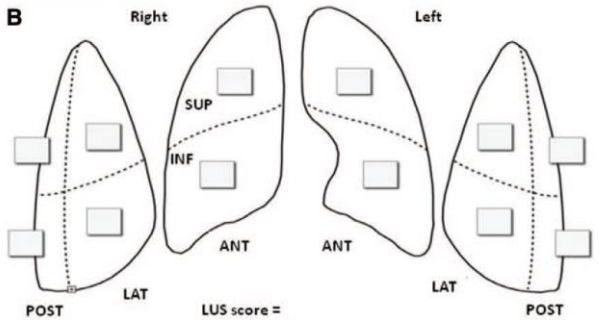
- Technical Aspects
- Locations
- Qualitative Finding
- Quantitative Finding
- Others

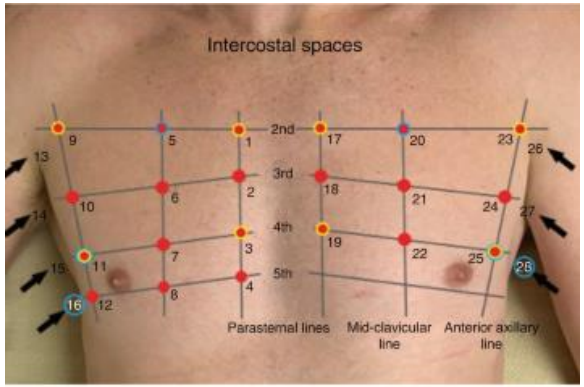
Lung Ultrasound Area (Comprehensive vs Focused)





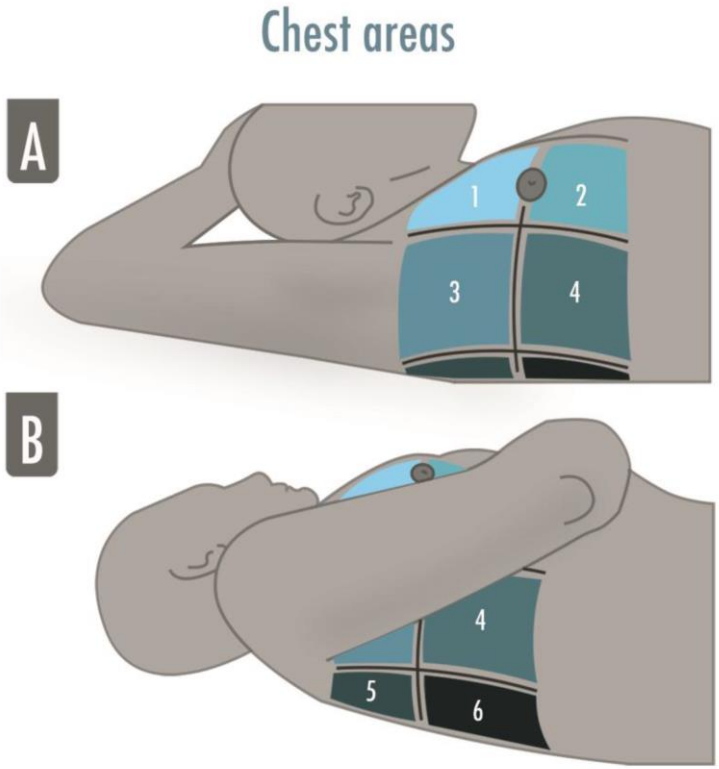






J Echocardiogr 2021;19:195-204

Comprehensive Approach



- parasternal line
- ant. axillary line
- post. axillary line
- paravertebral line
- mammillary line

Ant - 1/2

Lat - 3/4

Post - 5/6

Sup - 1,3,5
Inf - 2,4,6

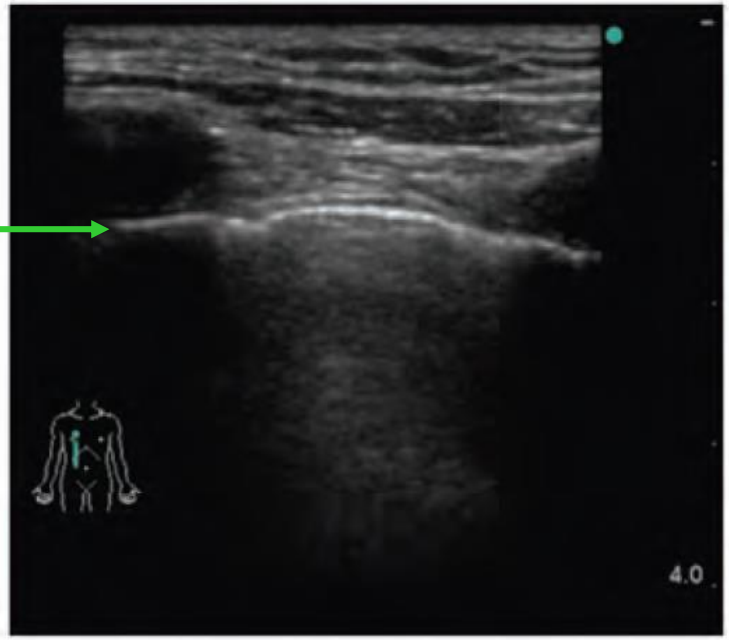
Rt 6 / Lt 6 (12 area)

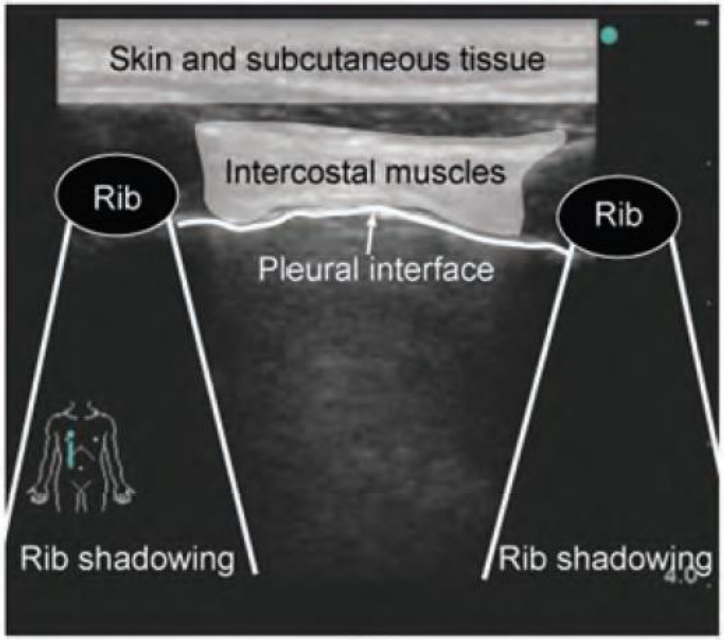
Adv Respir Med 2023;91:203-223

- Technical Aspects
- Locations
- Qualitative Finding (morphological assessment for the diagnosis)
- Quantitative Finding
- Others

Bat sign (longitudinal scan)

Parietal Pleura

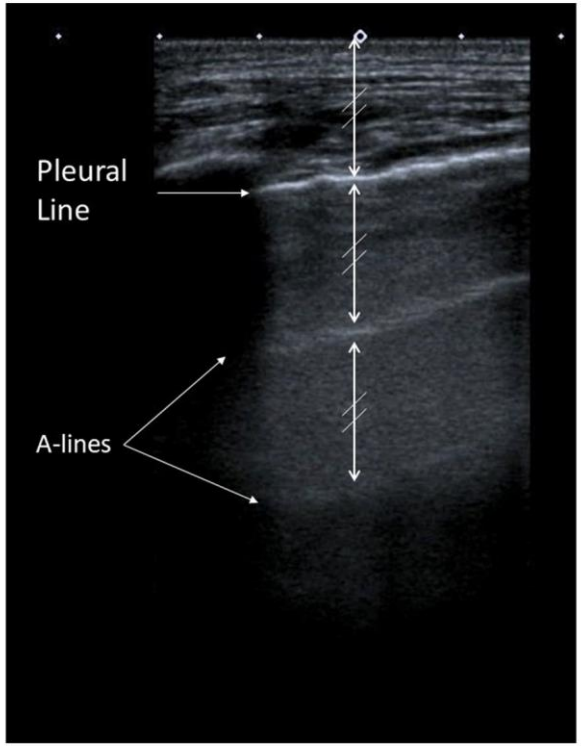


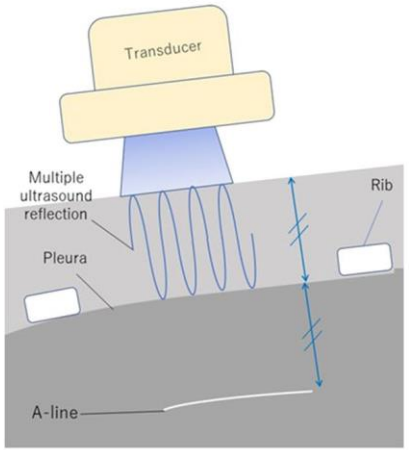


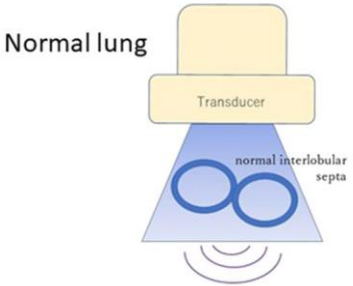
- Subcutaneous emphysema
- morbid obesity

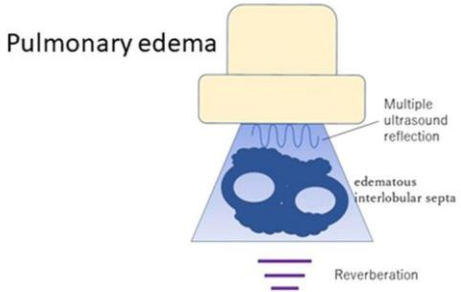
Curr Opi Anaesthesiol 2013;26:20-30

Ultrasound Setting



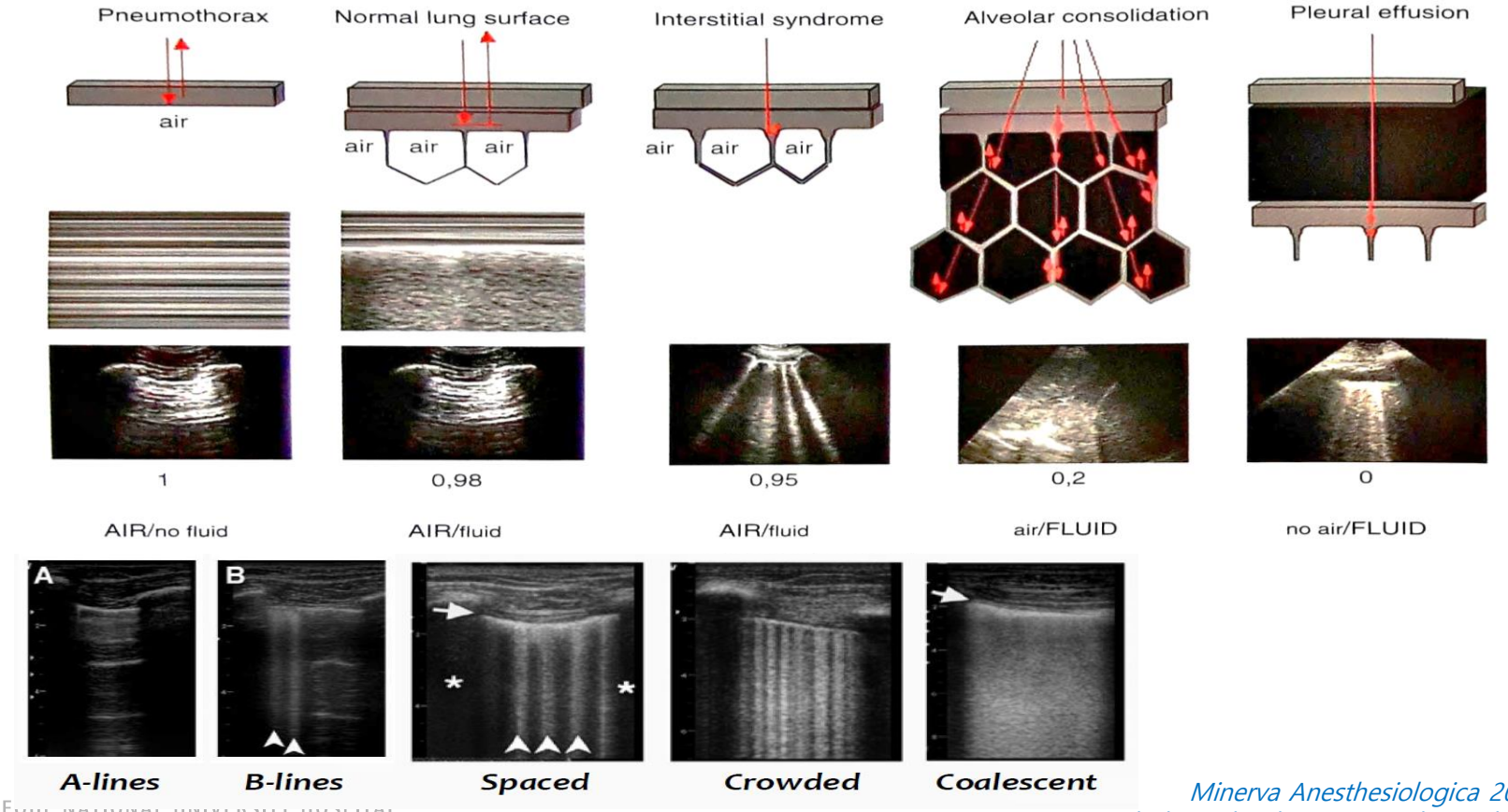






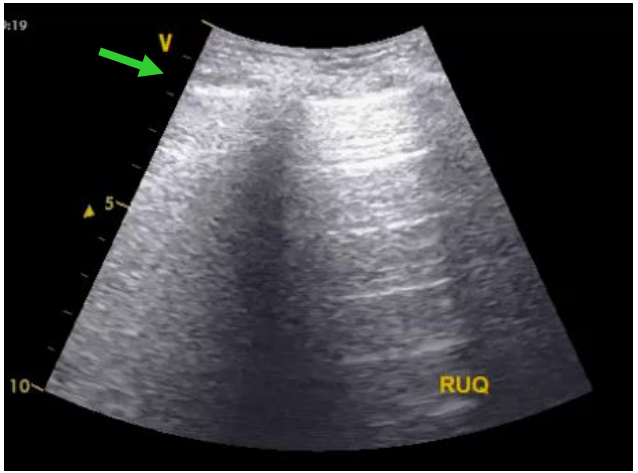
J Echocardiogr 2021;19:195-204

Artifacts

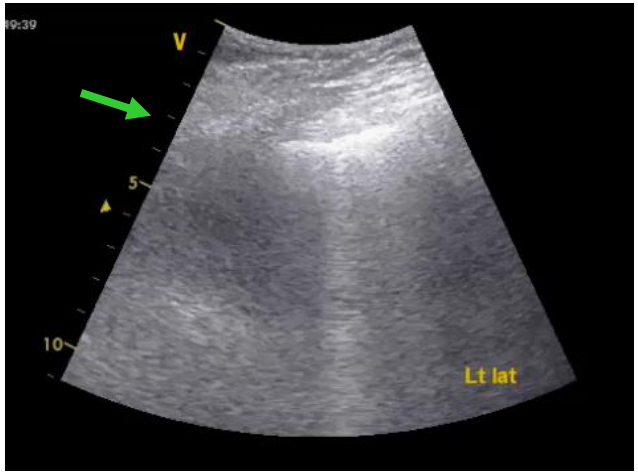


Minerva Anesthesiologica 2012;26:20-30
Whole Body Ultrasonography in the Critically Ill

A-line vs B-lines



- Horizontal artifact
- Parallel to pleural line
- Repeated, Equal distance (probe~pleura)
- Air beneath pleura
- High gas/volume ratio
- Reverberation

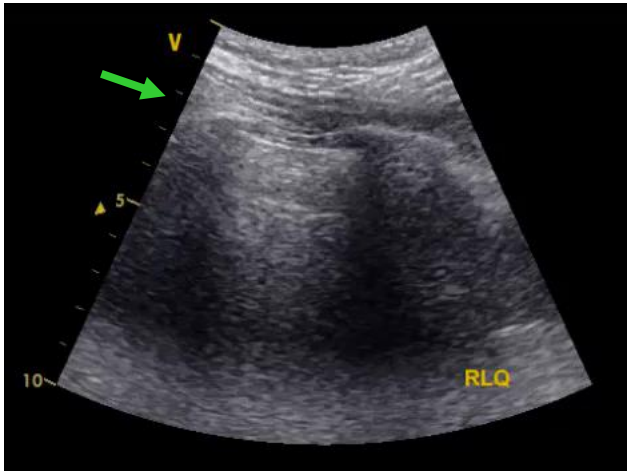


- Vertical artifact
- Move synchronously with pleura
- Erase the A-lines
- Reach to the bottom of the screen
- Increased density (air/tissue ratio)

Qualitative Finding

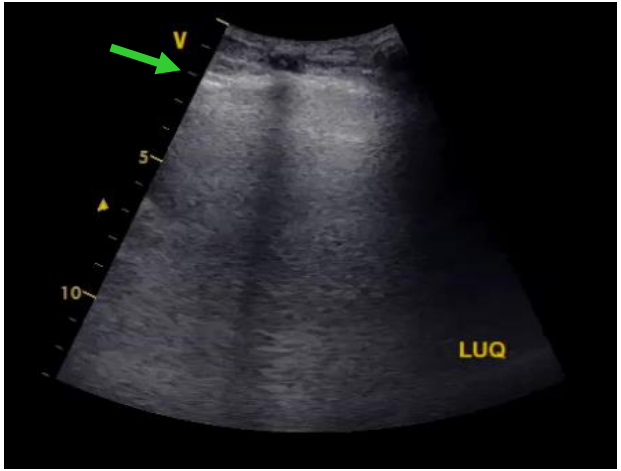
- Lung parenchyma
  - Aeration and density (A-line, B-lines, consolidation)
  - Lung water (B-lines)
  - Airway patency (air bronchogram)
- Pleura
  - Pleura thickening
  - Pleura movement (Lung sliding/Lung pulse/Lung point)
  - Pleural space (air/water/blood/others)

Lung Sliding vs Lung Pulse

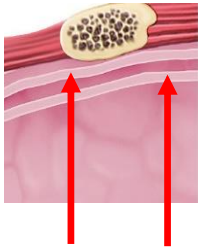


Lung Sliding

- visceral / parietal pleura in touch
- regional ventilation (+)

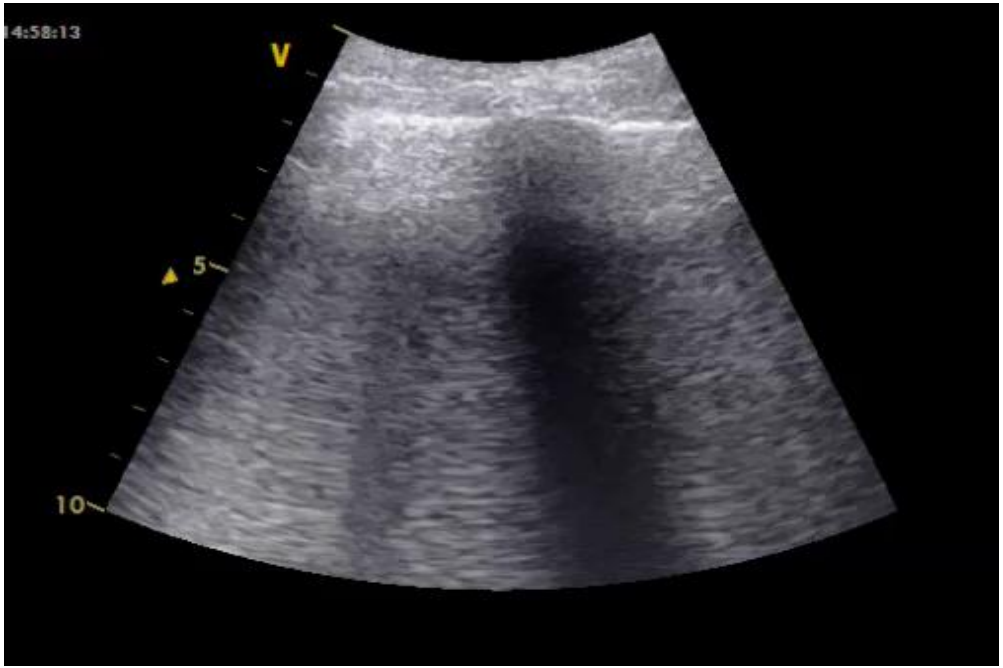


Lung Pulse



- transmission of the heart beats
- regional ventilation (-)
- selective intubation/initial phase of atelectasis, pul. contusion, hyperinflation

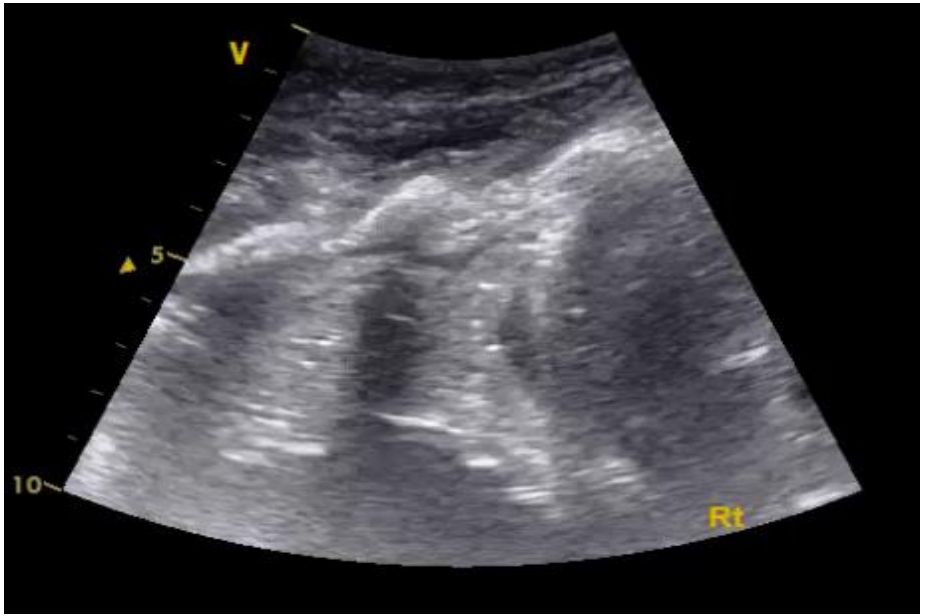
Interstitial Syndrome



edematous lung ~
cardiogenic pulmonary edema,
ARDS, pneumonia.....

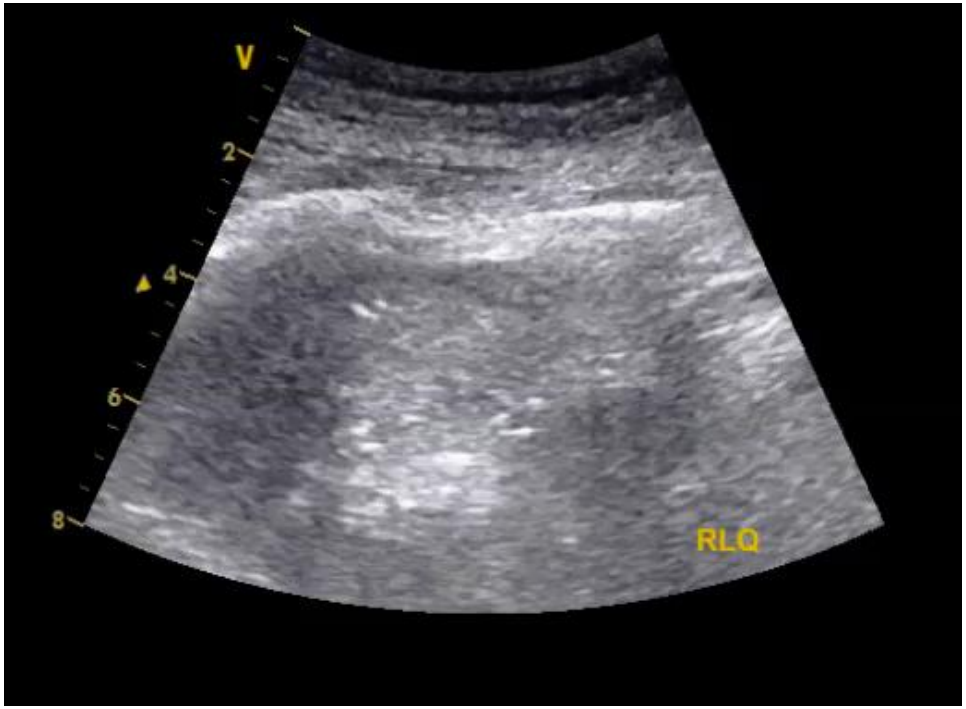
Consolidation

Shred sign

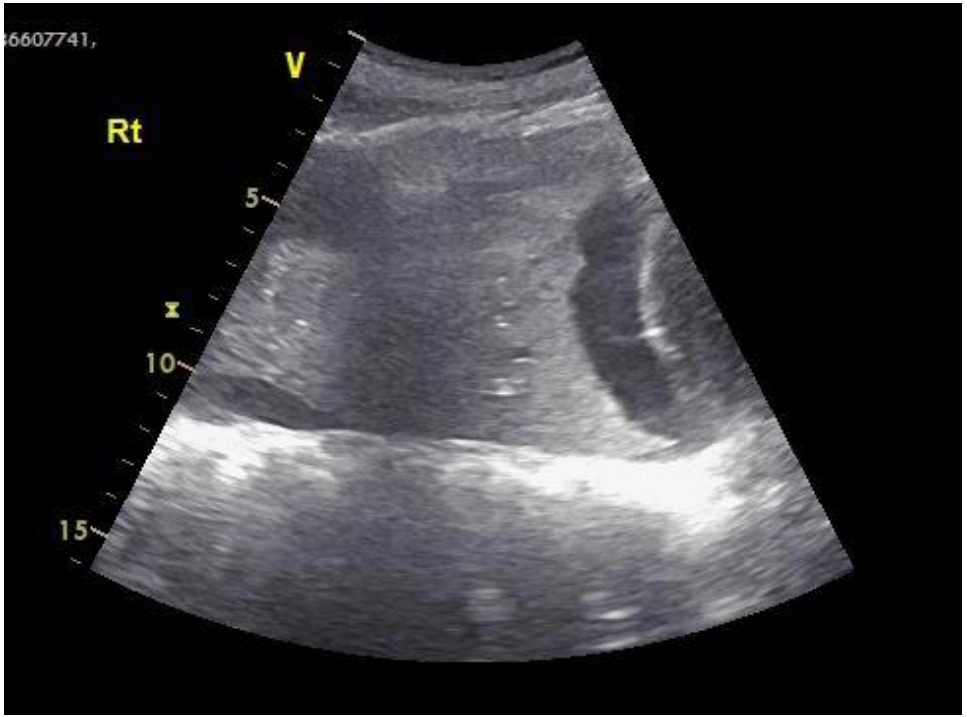


Tissue-like pattern

Dynamic Air Bronchogram



Pleural Effusion

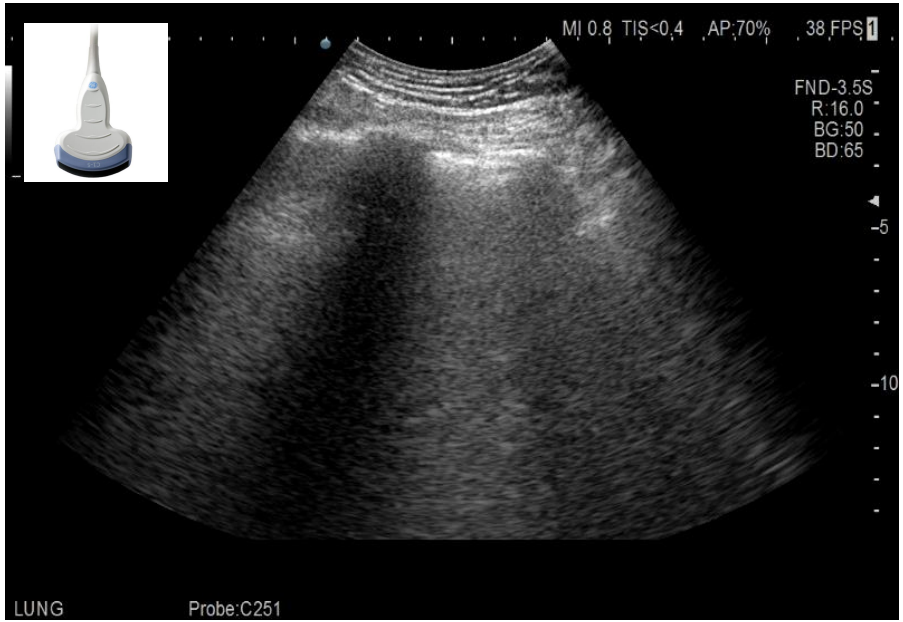


- transudative / exudative

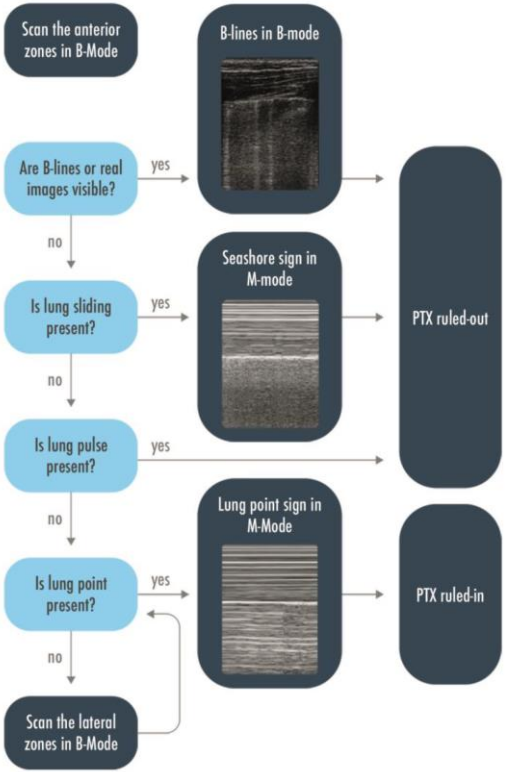
Lung Point

2D / M-mode

- Seashore sign
- Stratosphere sign



Pneumothorax



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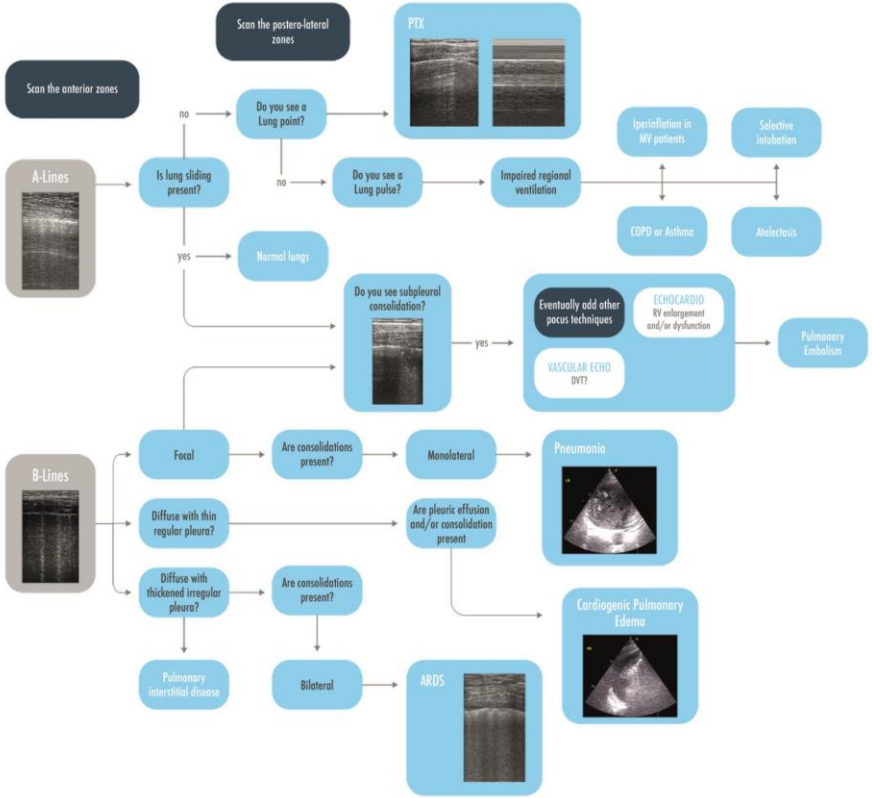
Hypoxemia



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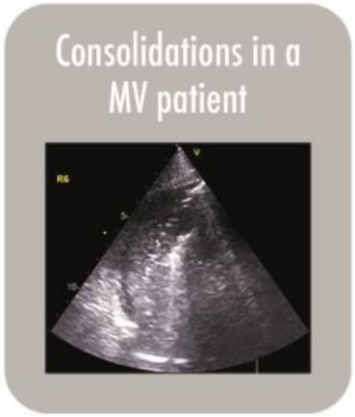
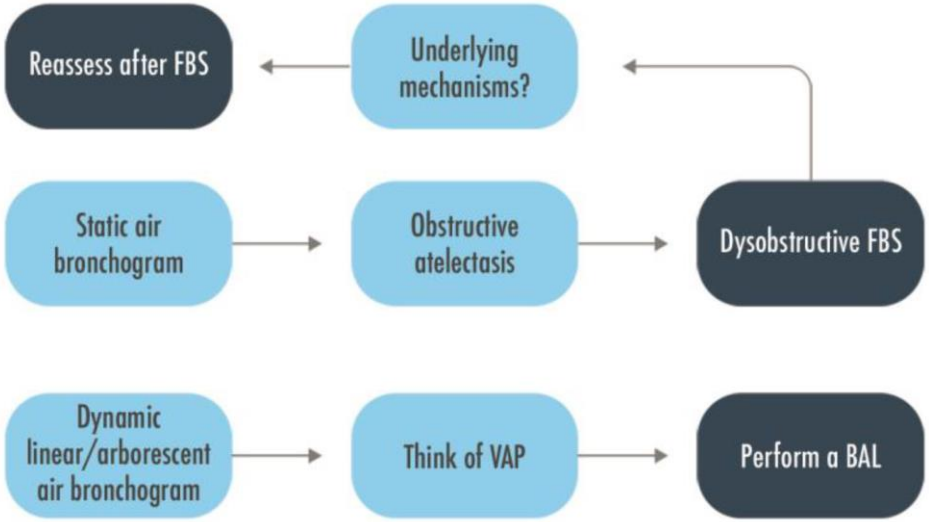
Consolidation on MV





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- Technical Aspects
- Locations
- Qualitative Finding
- Quantitative Finding (lung monitoring)
- Others

Lung Aeration Quantification Scores

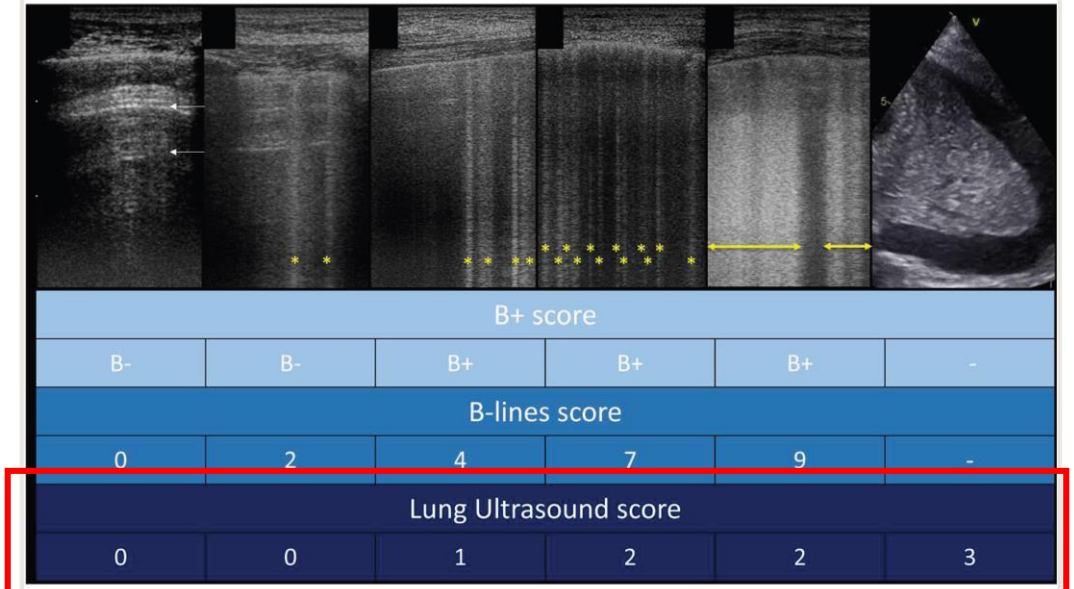
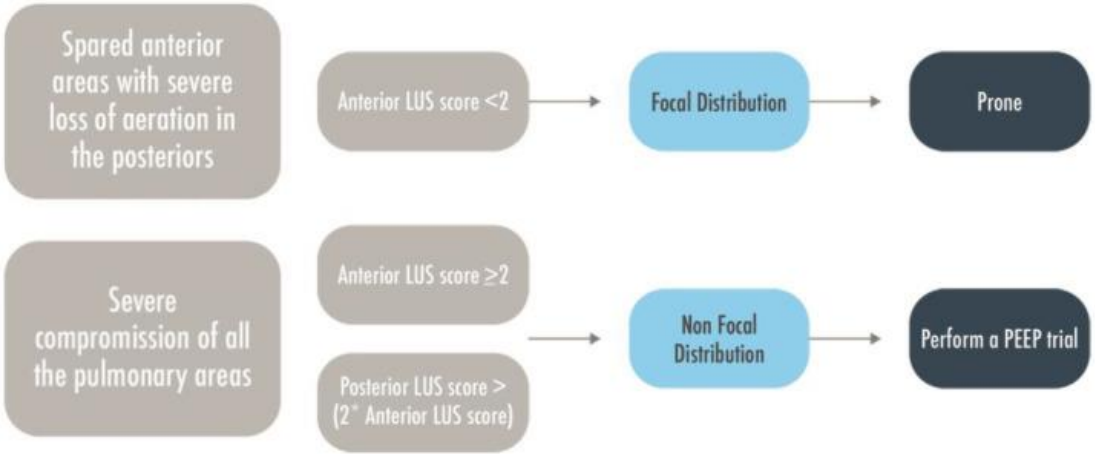


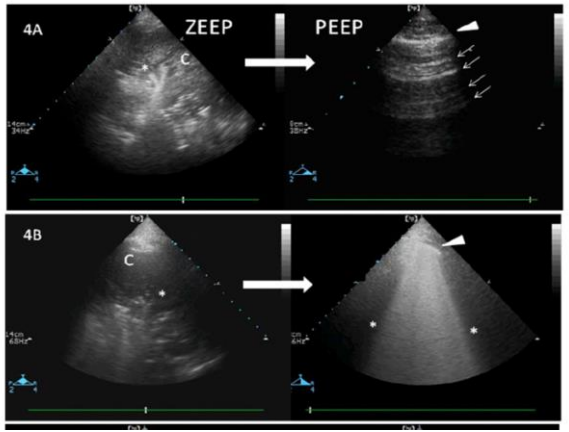
Fig. 4. Ultrasound patterns and corresponding scores in different rating systems for lung aeration quantification. *White arrows*, A-lines; *, well-spaced B-lines; *yellow double-point arrows*, coalescent B-lines.

- Rt/Lt (12 area) (0~36 scores)
- 0: normal aeration
  - A-line, B-lines<3
- 1: moderate loss of aeration
  - well-spaced B-line≥3
  - B-lines/subpleural consolidation<50%
- 2: severe loss of aeration
  - B-lines/subpleural consolidation>50%
- 3: complete loss of aeration
  - consolidation

Anesthesiology 2021;134:949-65

PEEP or Prone Position





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Systematic Ultrasound-Guided Approach to Weaning from MV

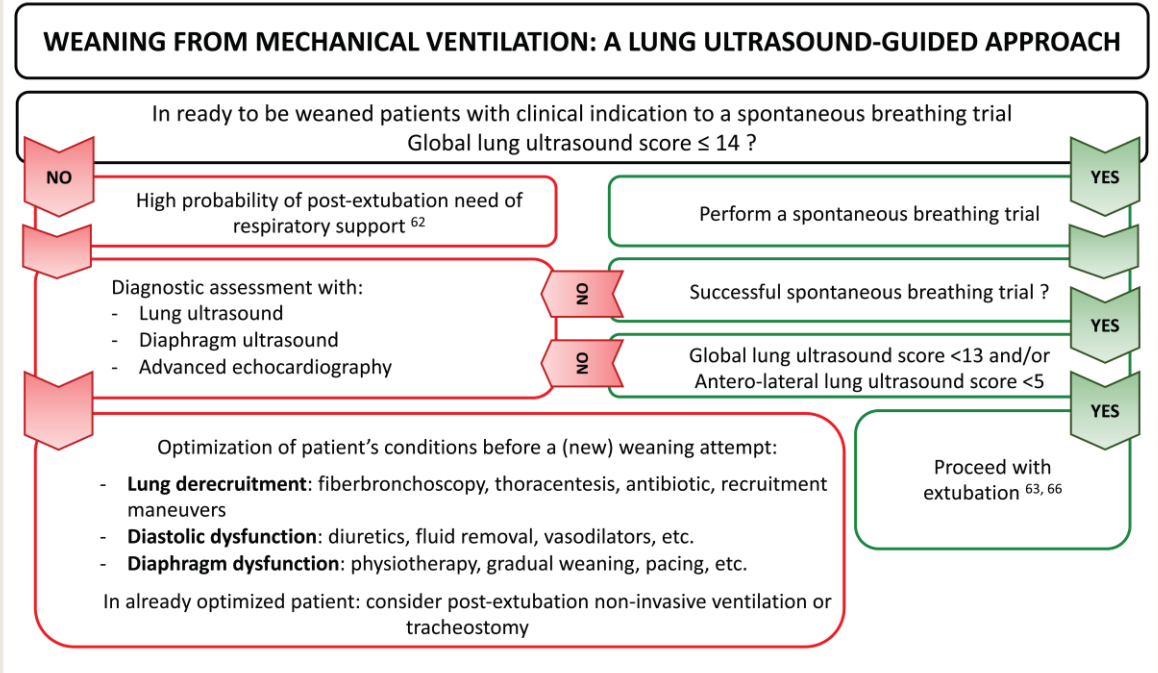

Fig. 6. A systematic ultrasound-guided approach to weaning from mechanical ventilation.

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Quantitative / Semiquantitative Approach

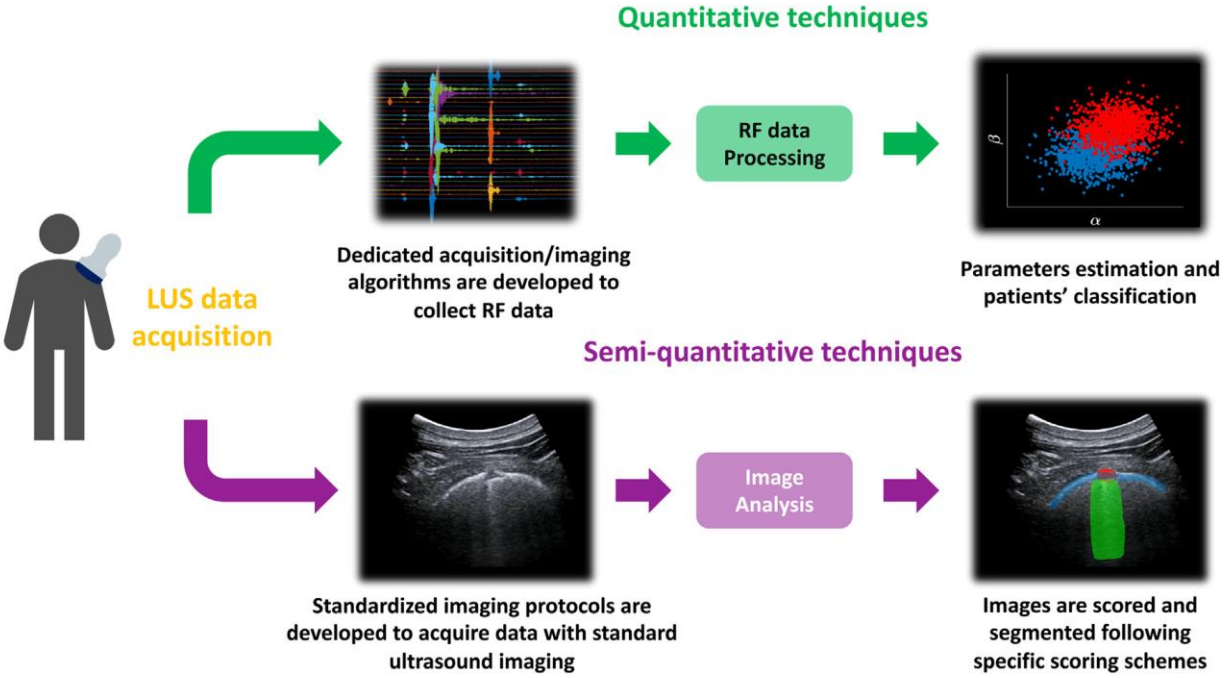


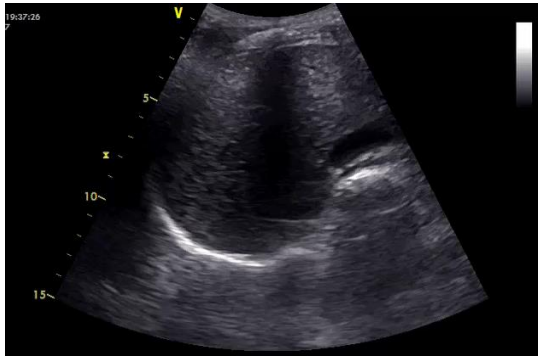
Fig. 2. Simplified flowchart depicting the different applications of quantitative and semiquantitative LUS techniques. LUS = lung ultrasound; RF = radiofrequency.

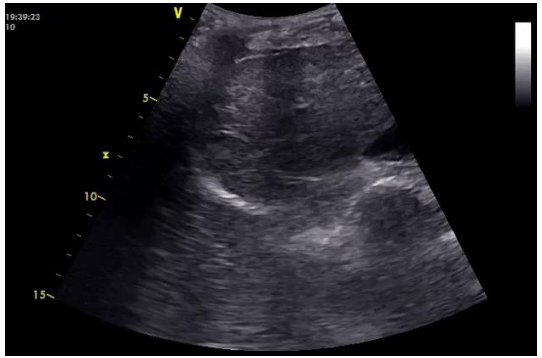
Ultrasound in Med & Biol. 2022;48:2398-2416

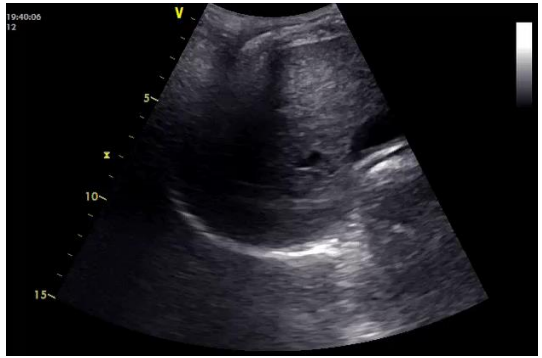
- Technical Aspects
- Locations
- Qualitative Finding
- Quantitative Finding
- Others (Heart, Diaphragm,...)

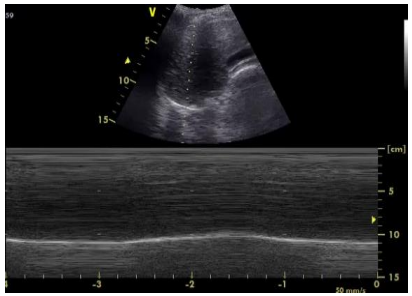
Diaphragm

Anterolateral

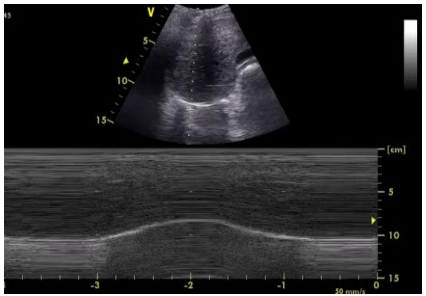




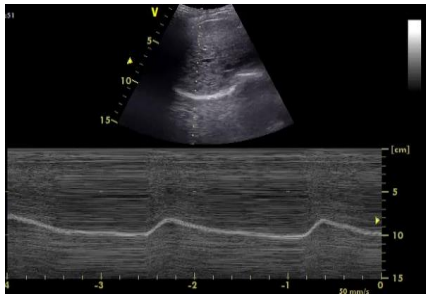




Quiet breathing



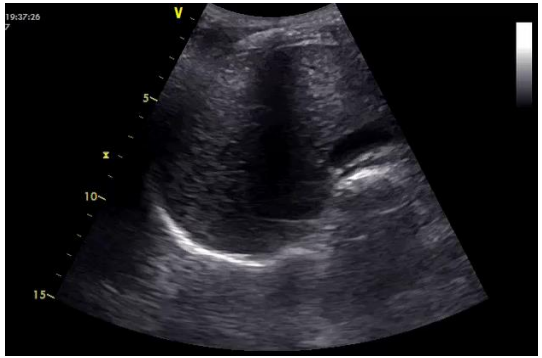
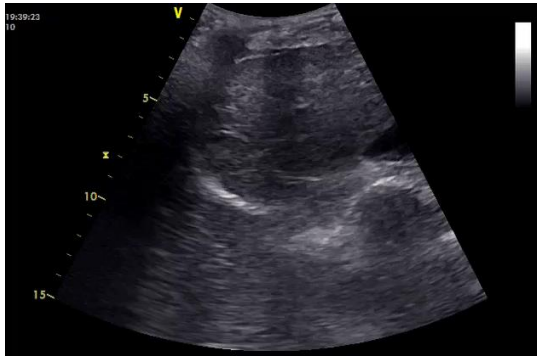
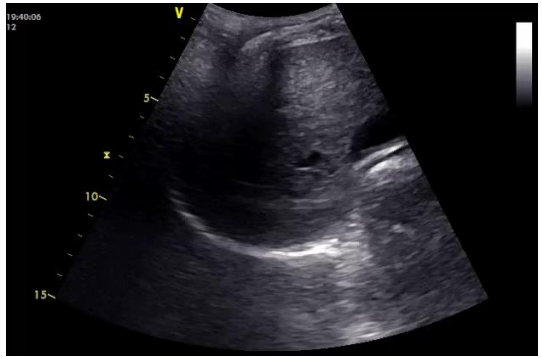
Deep breathing



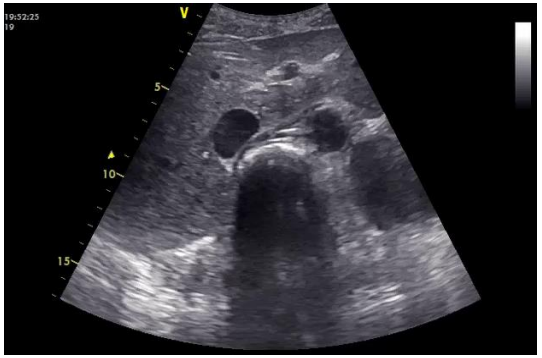
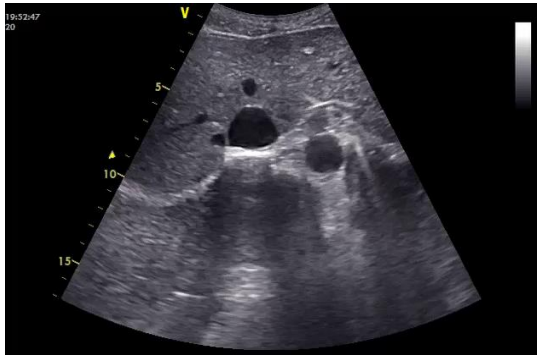
Sniffing

Diaphragm

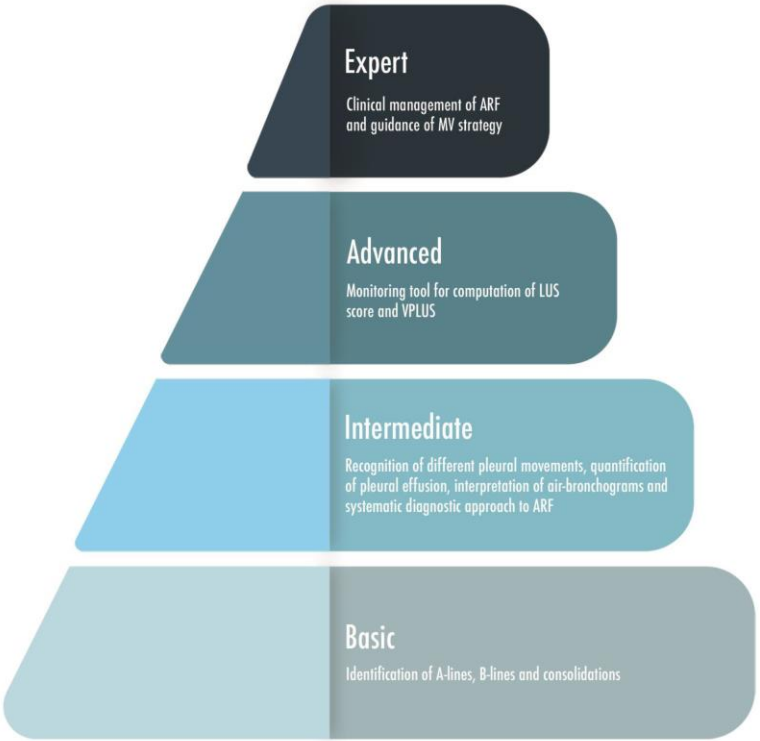
Anterolateral

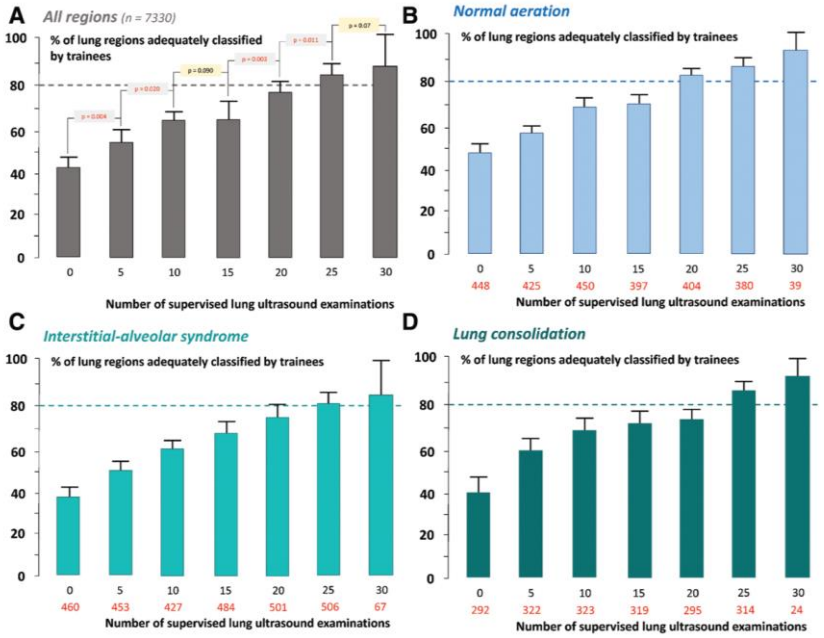




Subxiphoid


Quiet breathing | Deep breathing | Sniffing

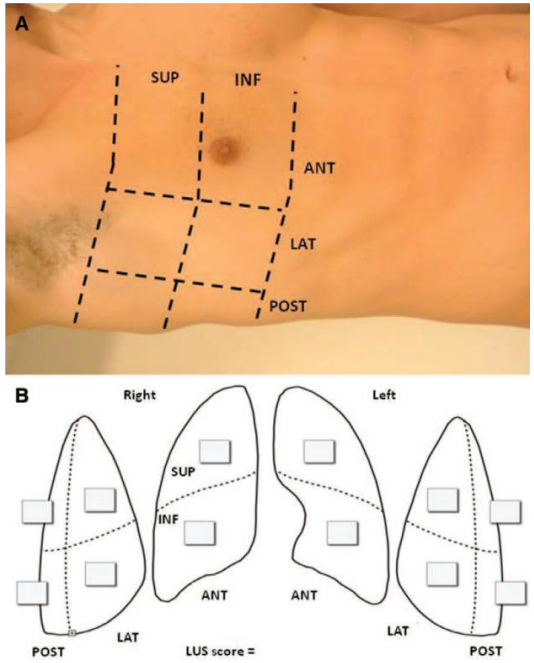




Adv Respir Med 2023;91:203-223
Anesthesiology 2020;132:899-907

Take Home Message

- **Region**



- Report details on technical part
  - frames / probes /imaging settings
- Approach
  - ant linear probe
  - lat / post convex probe
  - longitudinal / transversal scan
- describe limitation of the area
  - clinical condition
  - limited accessibility
  - other practical aspects
- Consensus for the terminology

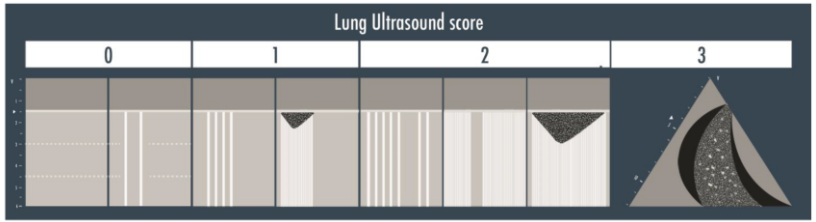
Take Home Message

▪ Qualitative Approach

- **Diagnosis**
- A-line / B-lines / Consolidation
- Air bronchogram
- Lung sliding / Lung pulse / Lung point
- Pleural space (characteristics/amount)
- Systematic diagnostic approach of ARF

▪ Quantitative Approach

- **Monitoring, Management**
- LUS scores (0~36)



- Clinical management of ARF and guidance of MV strategy

▪ Others

- Diaphragm
- Airway…

Ultrasonographic report for lung and pleura

대한심장혈관흉부외과학회 초음파위원회

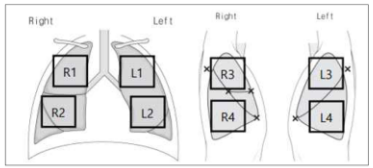
ID: Name: sex/age: /

1. Region
- R1 (anterior upper) / R2 (anterior lower) / R3 (lateral upper) / R4 (lateral lower)
- L1 (anterior upper) / L2 (anterior lower) / L3 (lateral upper) / L4 (lateral lower)

2. Right
- ☐ R1 / ☐ R2 / ☐ R3 / ☐ R4
  - ☐ Lung sliding
  - ☐ A-line
  - ☐ B-line
  - ☐ Pleural effusion
  - ☐ Alveolar consolidation
  - ☐ Lung point
  - ☐ others

3. Left
- ☐ L1 / ☐ L2 / ☐ L3 / ☐ L4
  - ☐ Lung sliding
  - ☐ A-line
  - ☐ B-line
  - ☐ Pleural effusion
  - ☐ Alveolar consolidation
  - ☐ Lung point
  - ☐ others

4. other findings



Take Home Message

- Consensus for the terminology
- Report details on technical part
  - frames
  - probes
  - imaging settings
    - ✓ output levels
    - ✓ mechanical index
    - ✓ imaging frequency
    - ✓ focal depth, imaging depth…

응급▪ 중환자 초음파

항목	세부인정사항
대상	쇼크 등 응급상황의 원인 감별, 급성 병변 판정, 치료 방침 결정, 처치·시술 시 보조(천차 및 카테터 삽입 시) 등 빠른 의사결정 및 정확하고 안전한 처치를 위해 초음파 검사가 필요한 환자
요건	초음파 장비가 설치된 중환자실이나 응급실에서 의사가 직접 시행, 검사 결과 등 진료기록부에 기재 (단, 복합 표적 초음파는 응급상황 발생으로 해당 요양기관의 이외 장소에서 검사한 경우에도 인정)
산정	단일 표적 초음파 (1부위 또는 2부위, 두경부/흉부/심장/복부/생식기/사지) 복합 표적 초음파*

- 복합 표적 초음파

(가) 적응증 : 급성 흉부·복부·골반 외상, 심정지, 쇼크나 불안정한 혈류역학, 호흡곤란, 흉통
(나) 실시인력 : 응급의학과 전문의(전공의), 외과계 전문의(외상외과 분야에 한함), 중환자실 전담의
(다) 검사범위 :흉부, 심장, 복부골반을 모두 포함하여 검사해야 하며, 필요 시 두경부, 사지 등을 추가 검사한 경우