Lung ultrasound in COPD

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Historical meaning of ultrasound at thorax

The lung is a major ***hindrance*** *for the use of ultrasound at the thoracic level.*

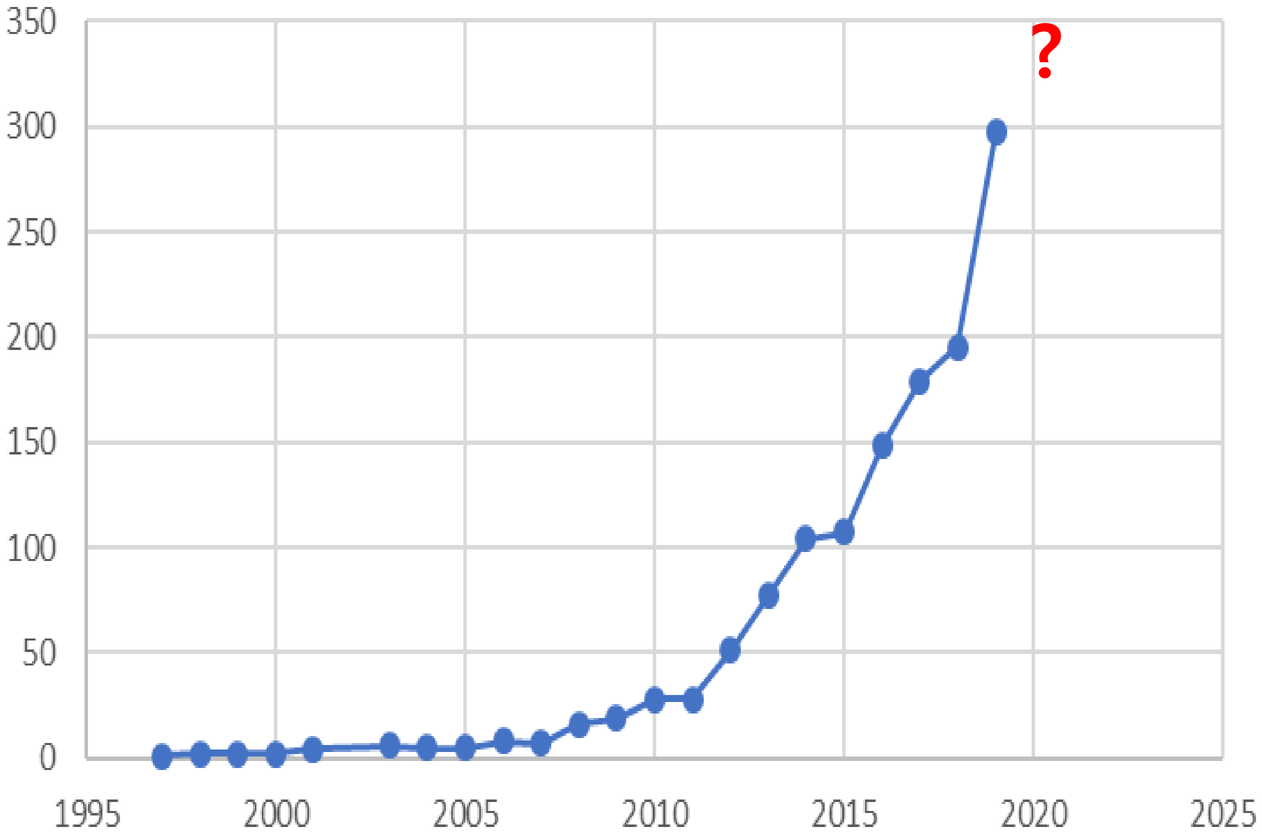
1992, TR Harrison, Principles of Internal Medicine

Ultrasound imaging is ***not useful*** *for evaluation of the pulmonary parenchyma.*

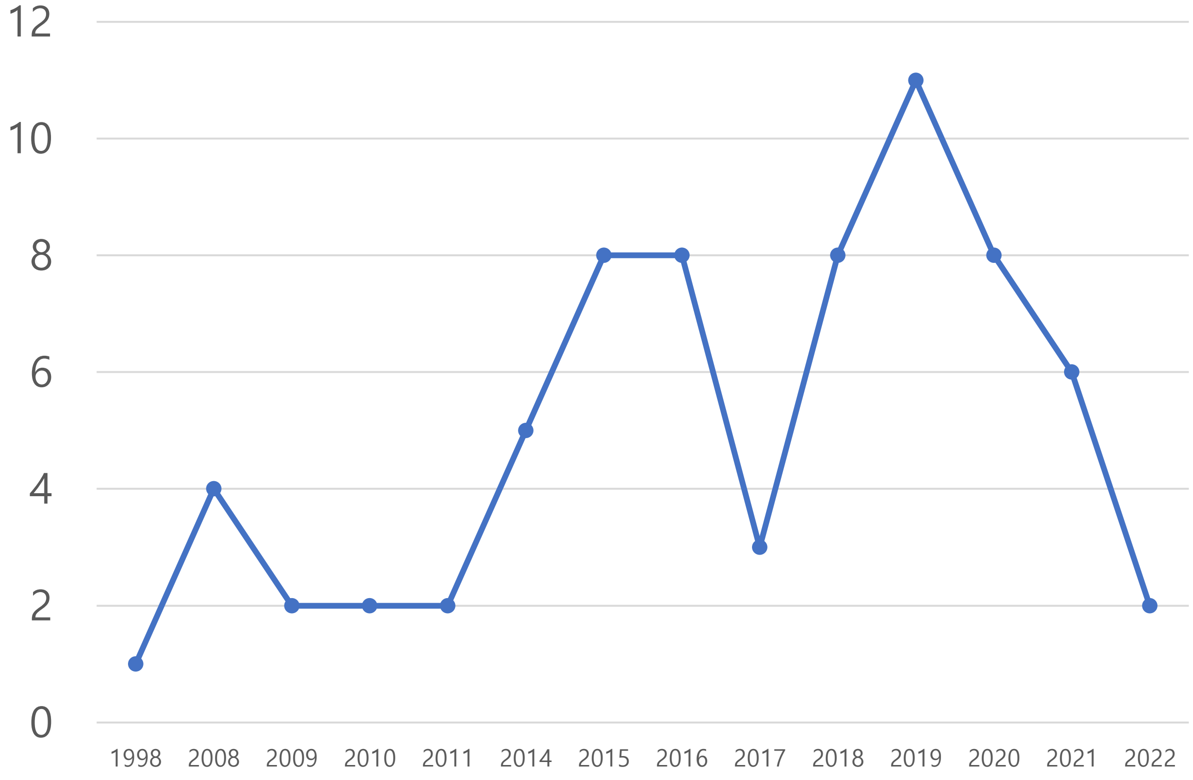
2001, TR Harrison, Principles of Internal Medicine

In research fields,

Pubmed search : #lung ultrasound #thoracic ultrasound



Pubmed search : #lung ultrasound #COPD



Basics of the lung ultrasound

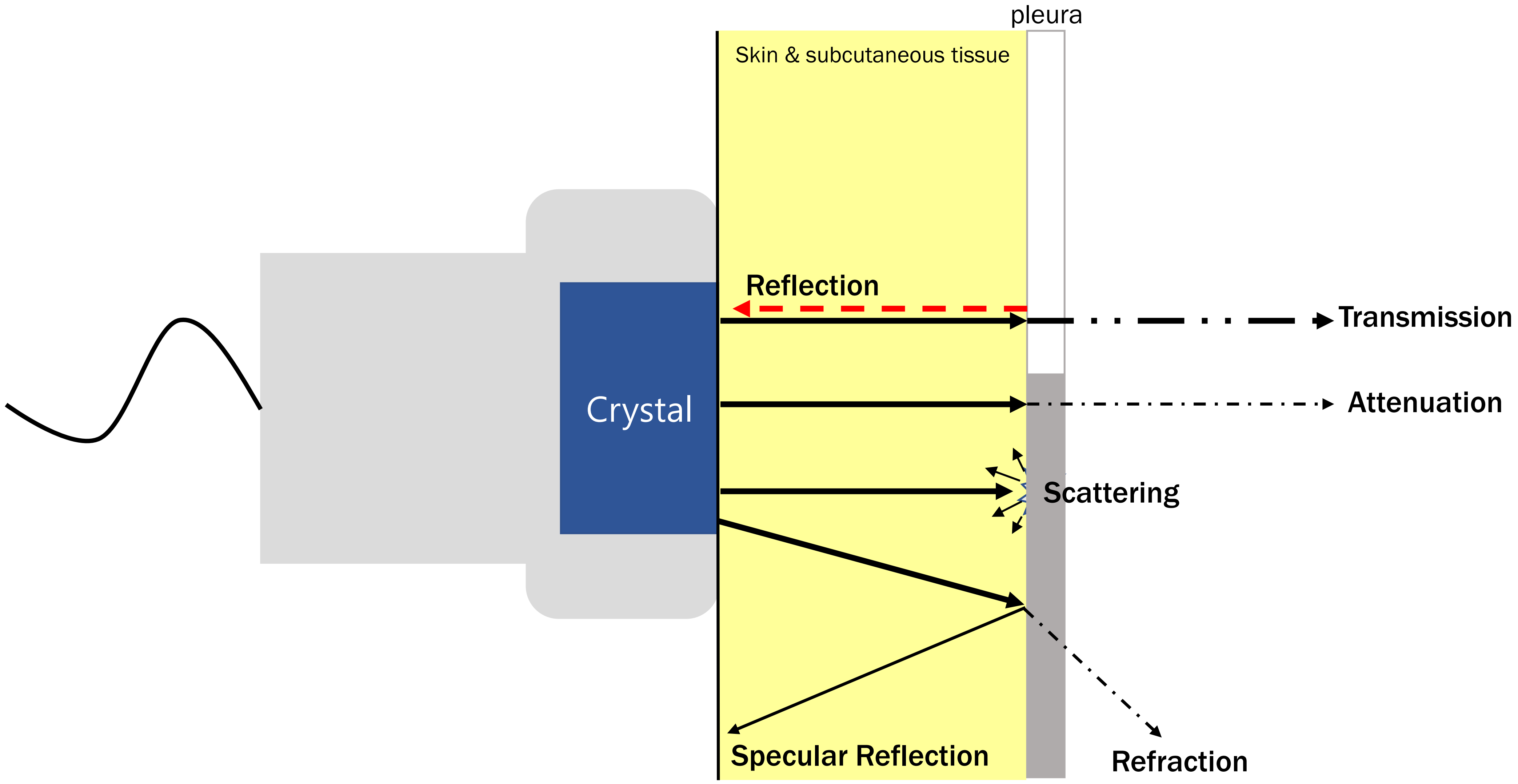
Basic physics of ultrasound

- **Ultrasound**

- Sound wave higher than the upper audible limit of human hearing (≥ 20kHz)

- Vibration through a transmission media (gas, liquid, and solid)

Basic physics of the lung ultrasound



Images of the lung ultrasound

- Real image

  : pleural effusion and consolidation

- **Artifacts**

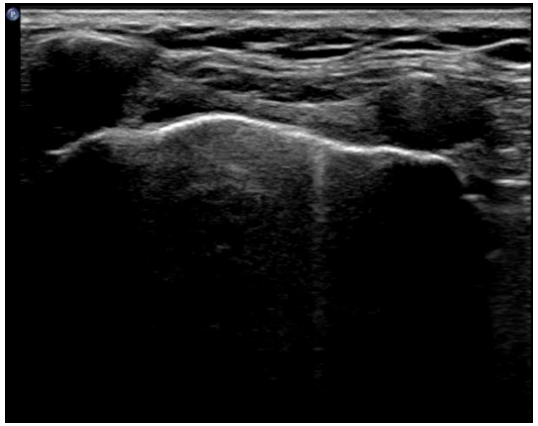
  : reverberation, acoustic shadowing, mirror image, and comet-tail etc.

Lung ultrasound artifacts

Examples of artifacts in lung

- Reverberations (A-line)
- Reverberations (B-line)
- Comet-tail artifact
- Acoustic shadowing
- Mirror image

Reverberation (A-line)



Comet-tail

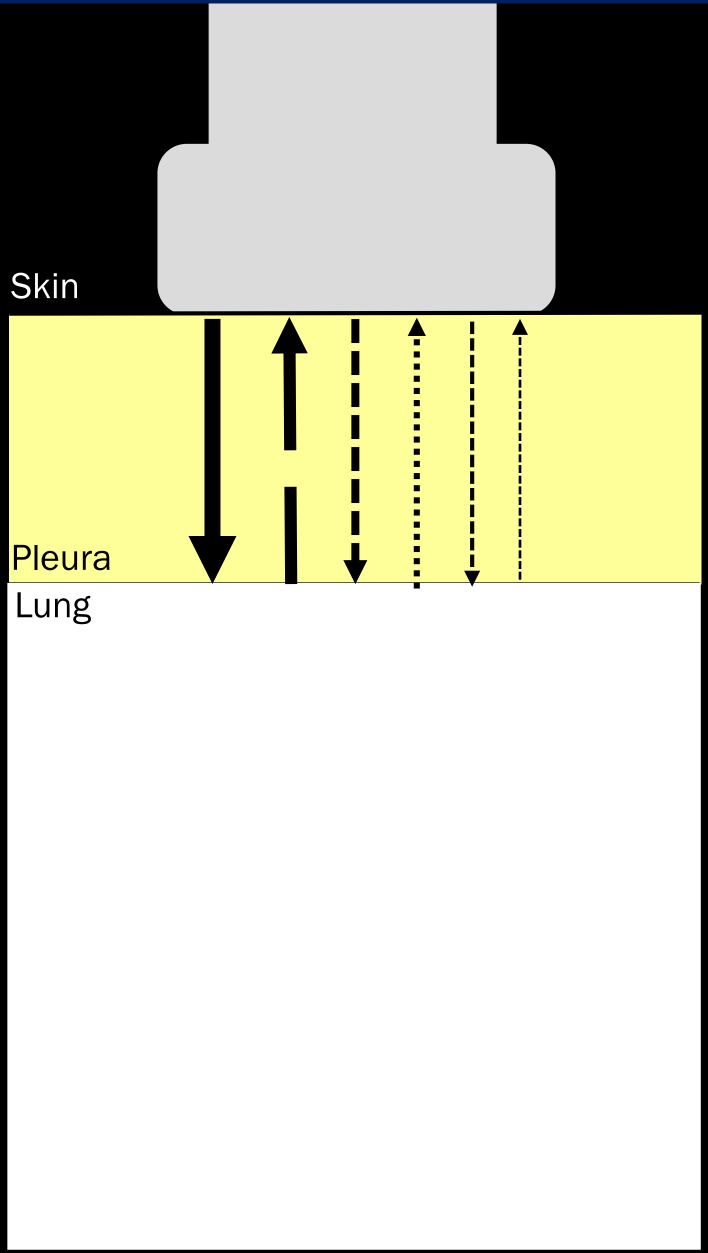
Reverberation (B-line)

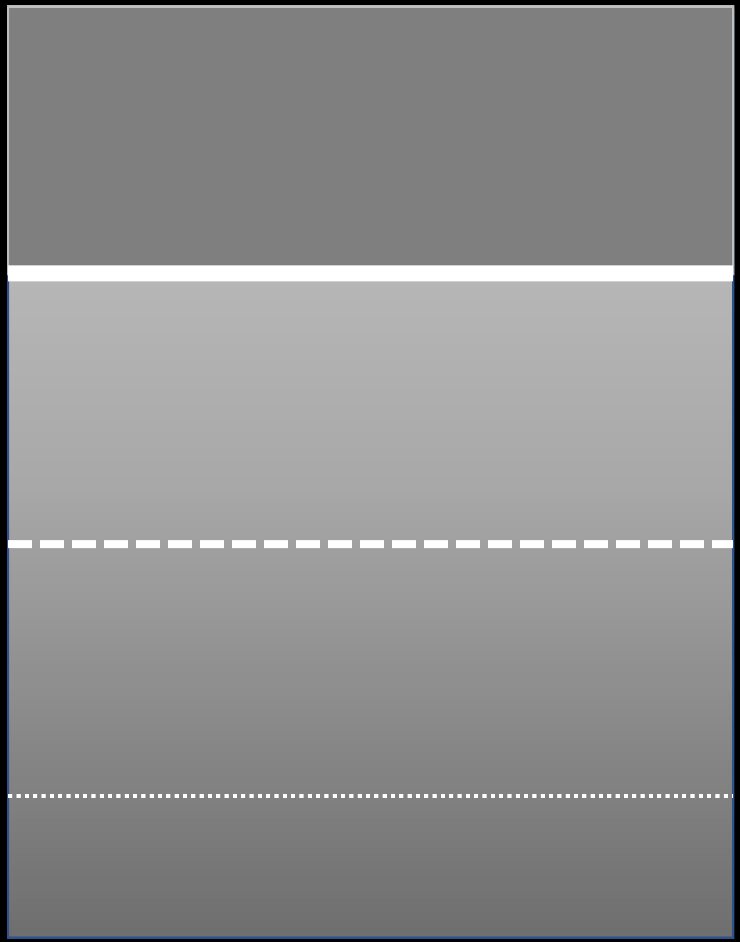
Acoustic shadowing

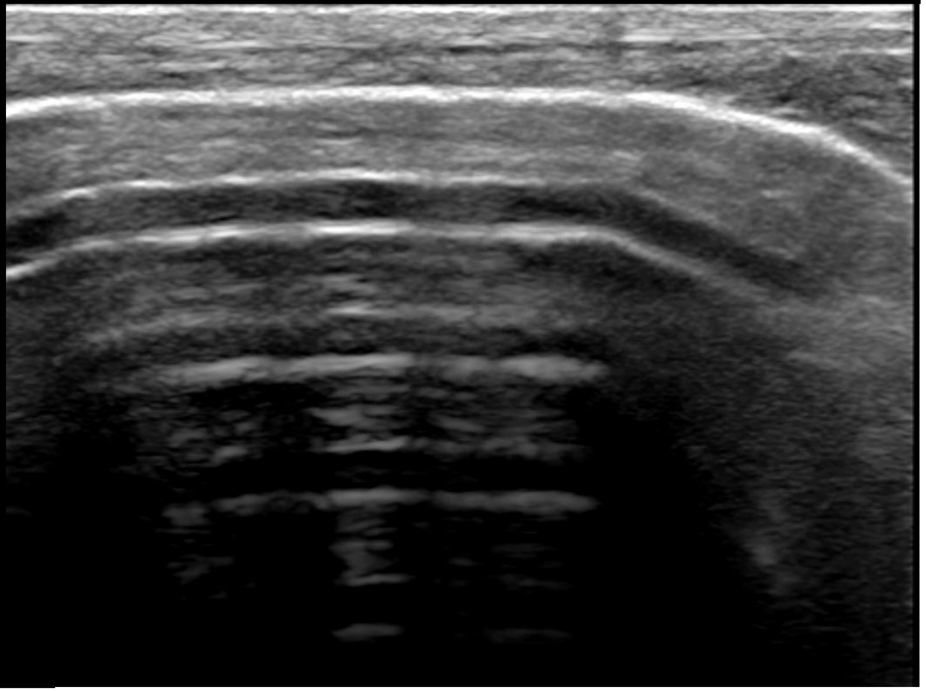
Mirror image

Philip Lumb. Chapter artifacts, Critical Care Ultrasound

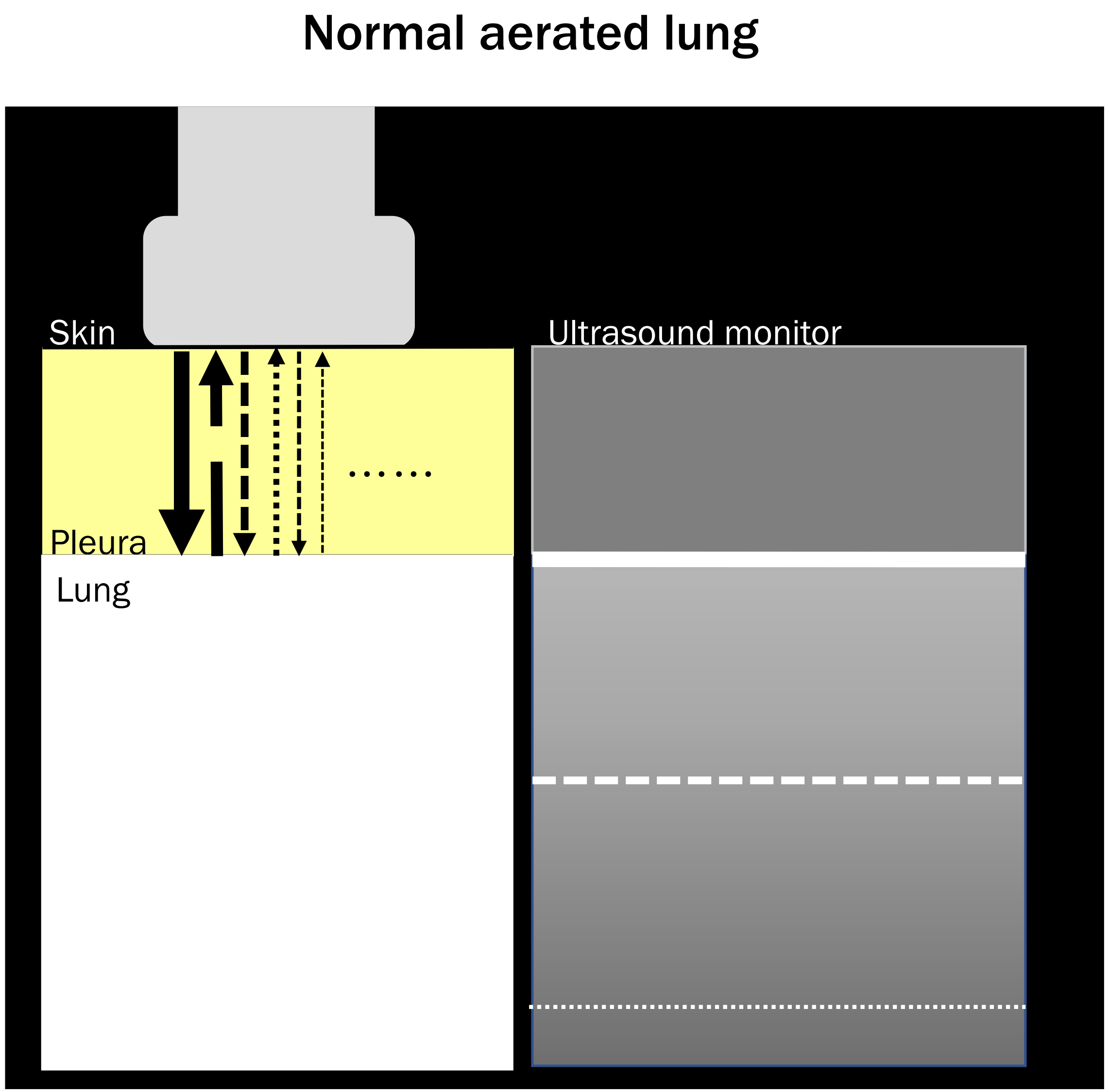
Reverberation – Long path, A-line

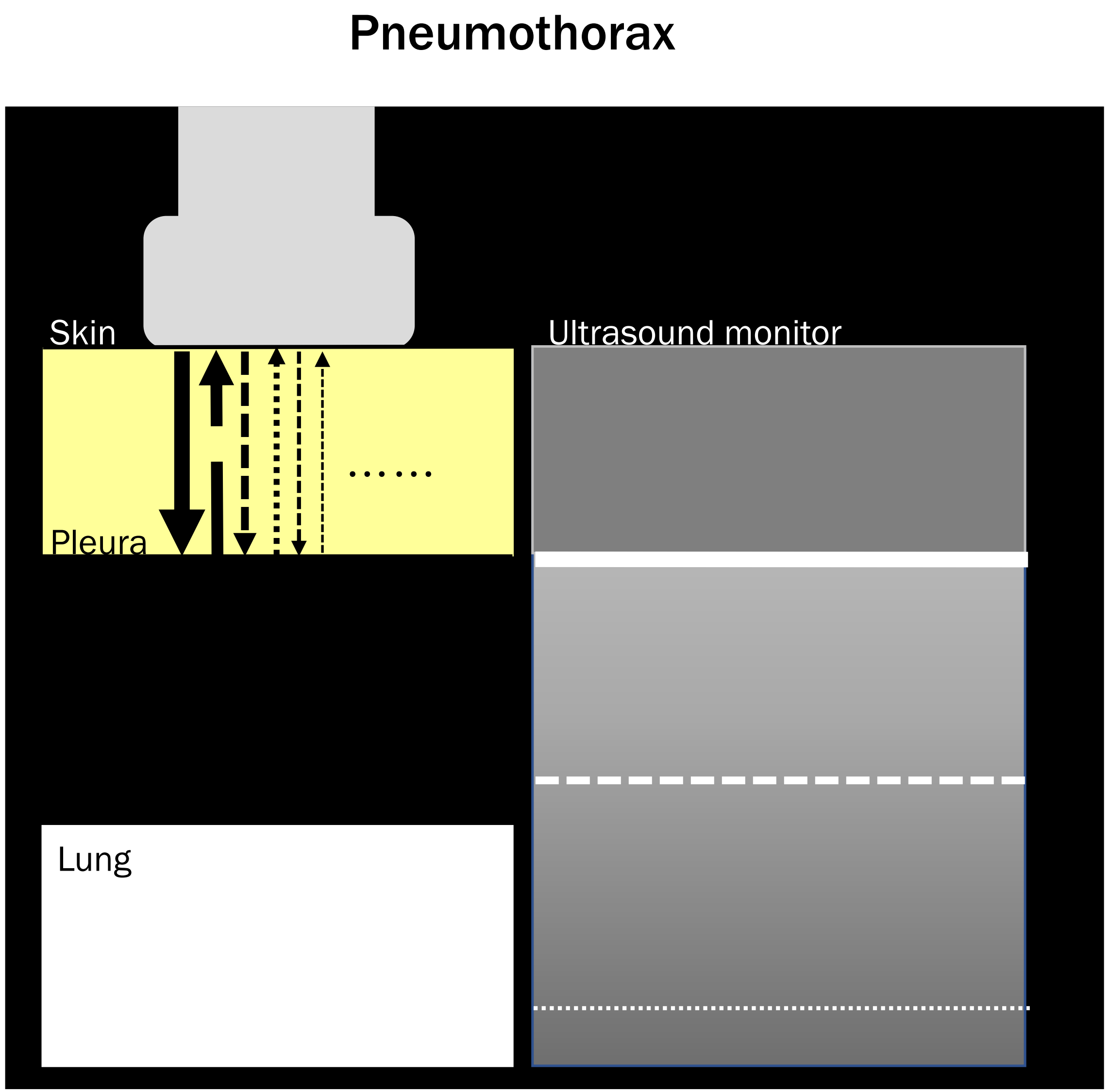






Reverberation – Long path, A-line

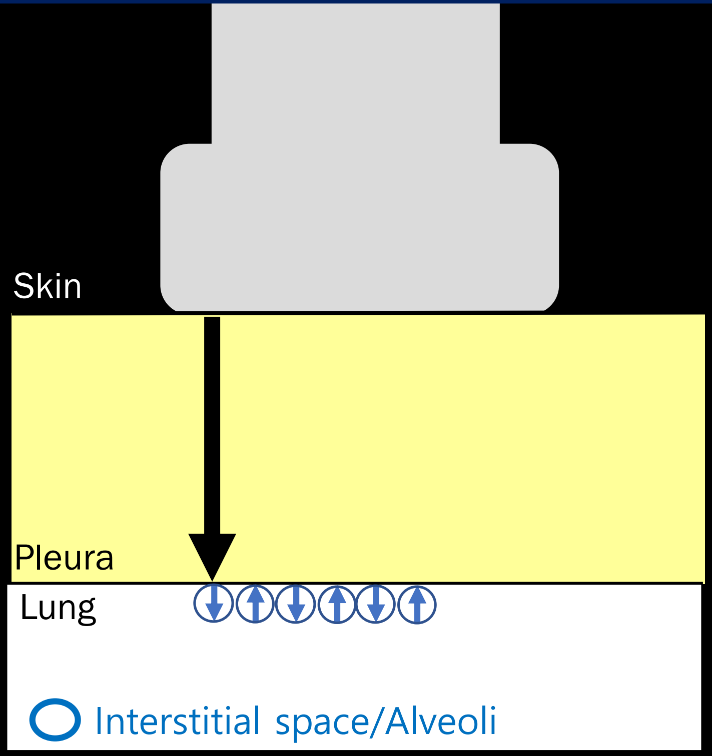


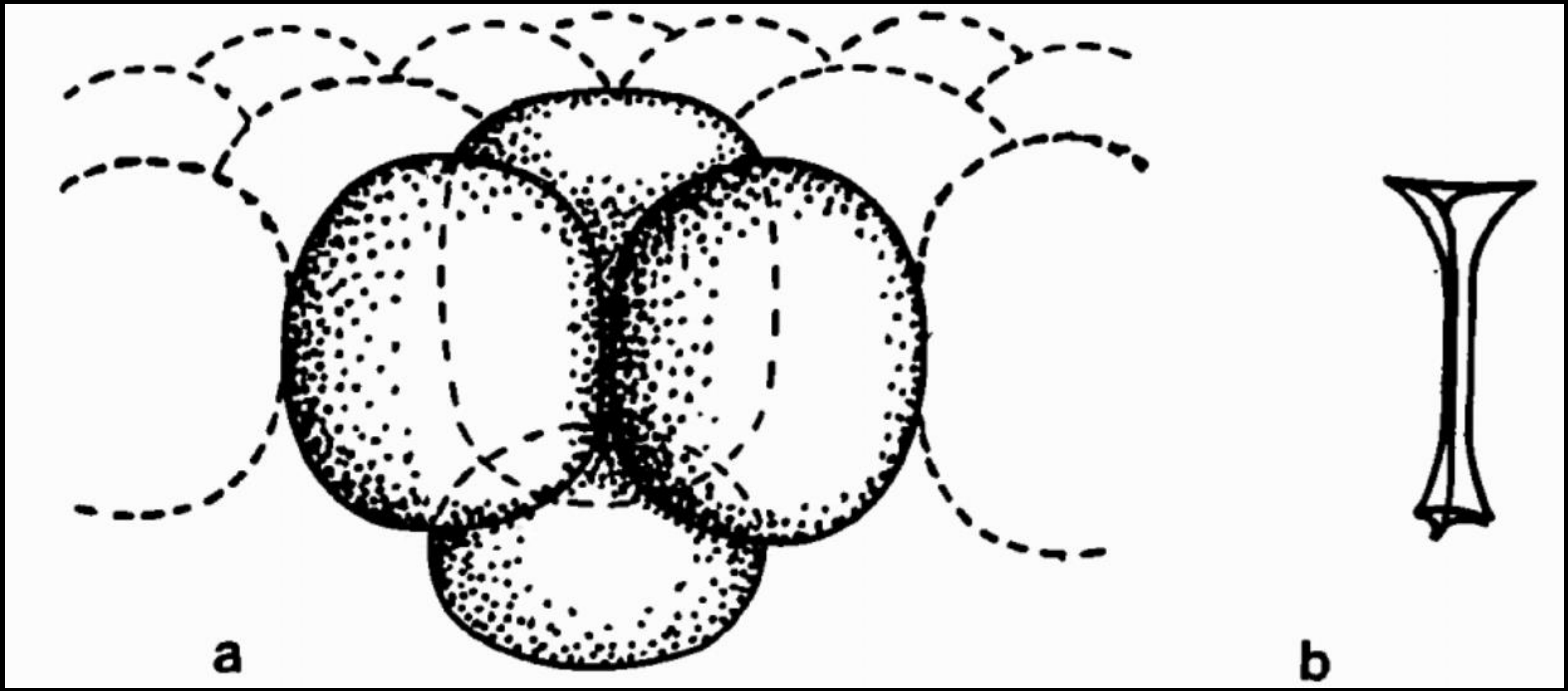


Reverberation – Long path, A-line

- A-line = Air
- Good aerated lung or hyperinflated lung (A-profile)
- Air outside of the lung (pneumothorax)

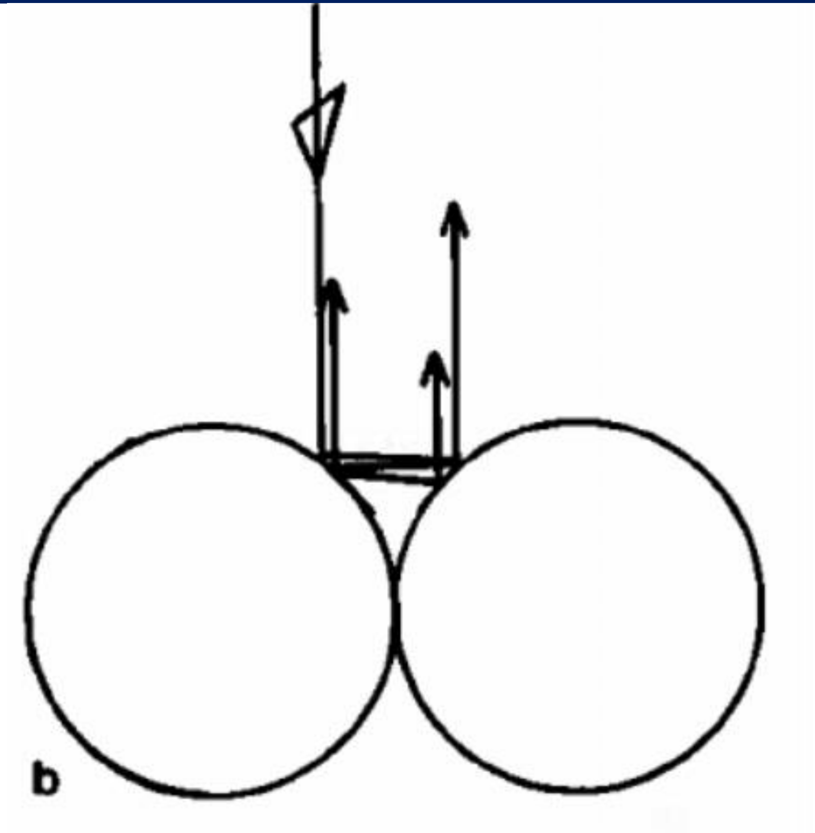
Reverberation – Short path, B-line, Ring-down

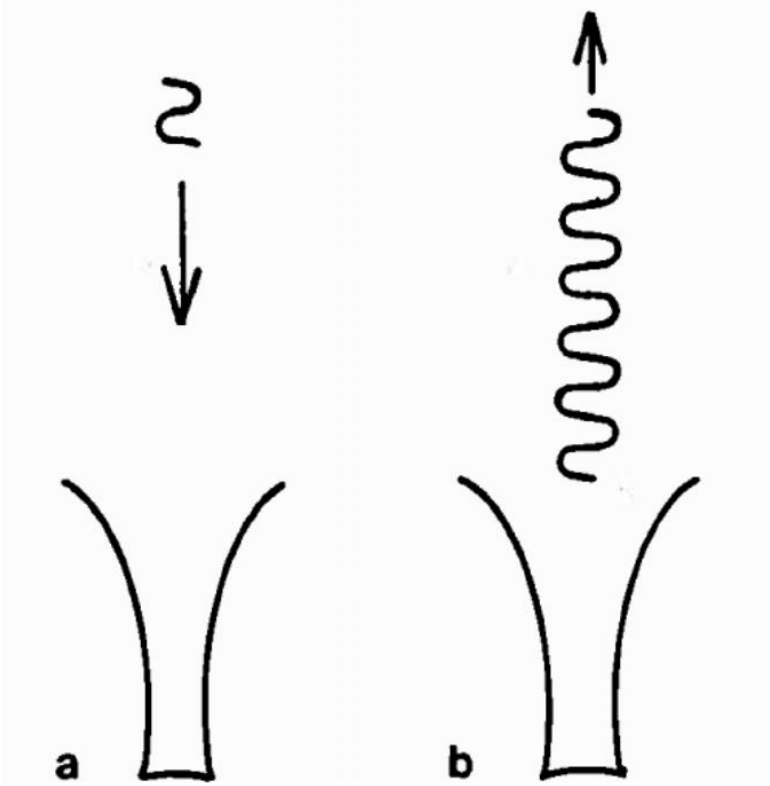




Avrush et al. Journal of Ultrasound in Medicine. 1985

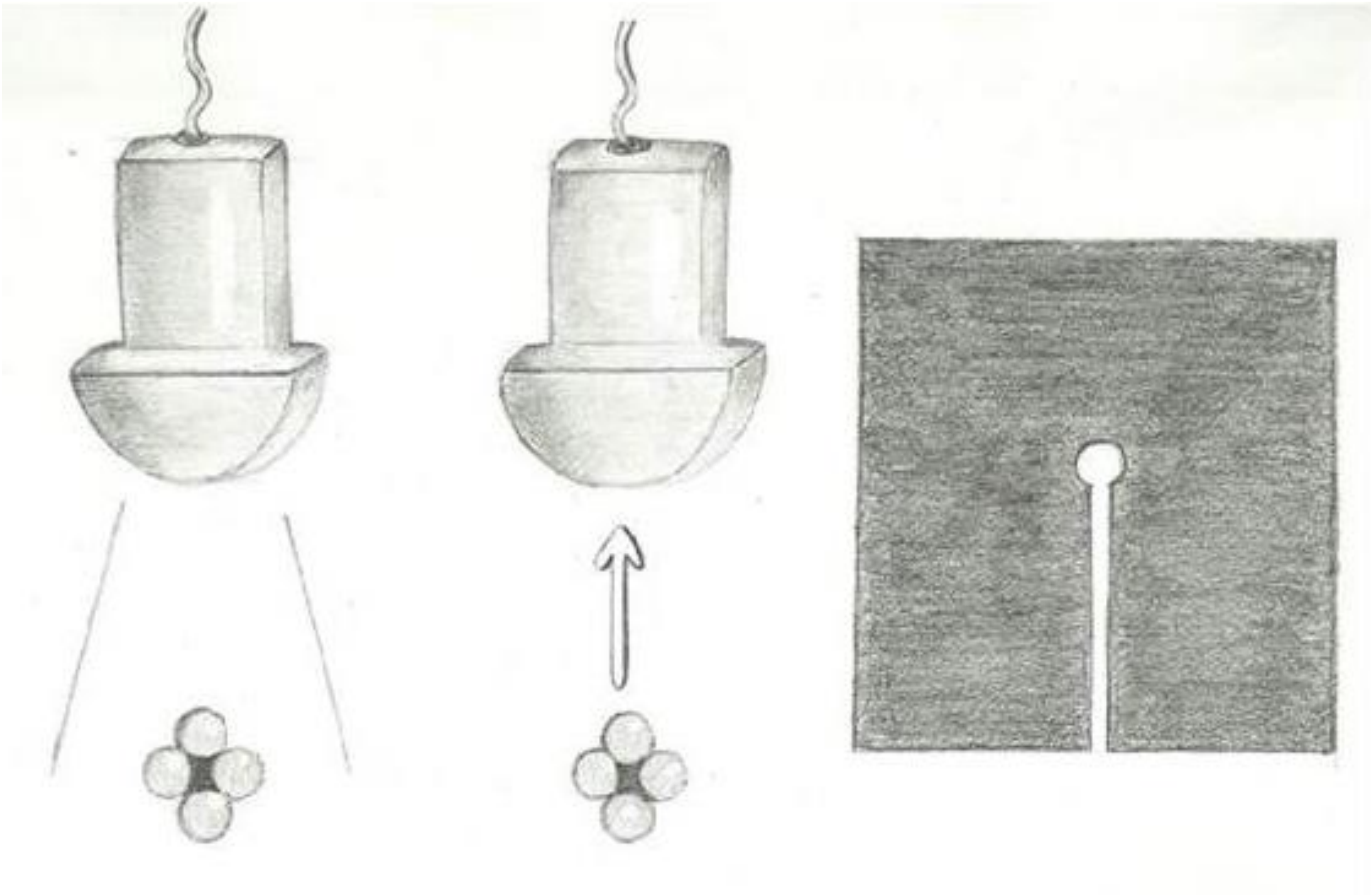
Reverberation – Short path, B-line, Ring-down



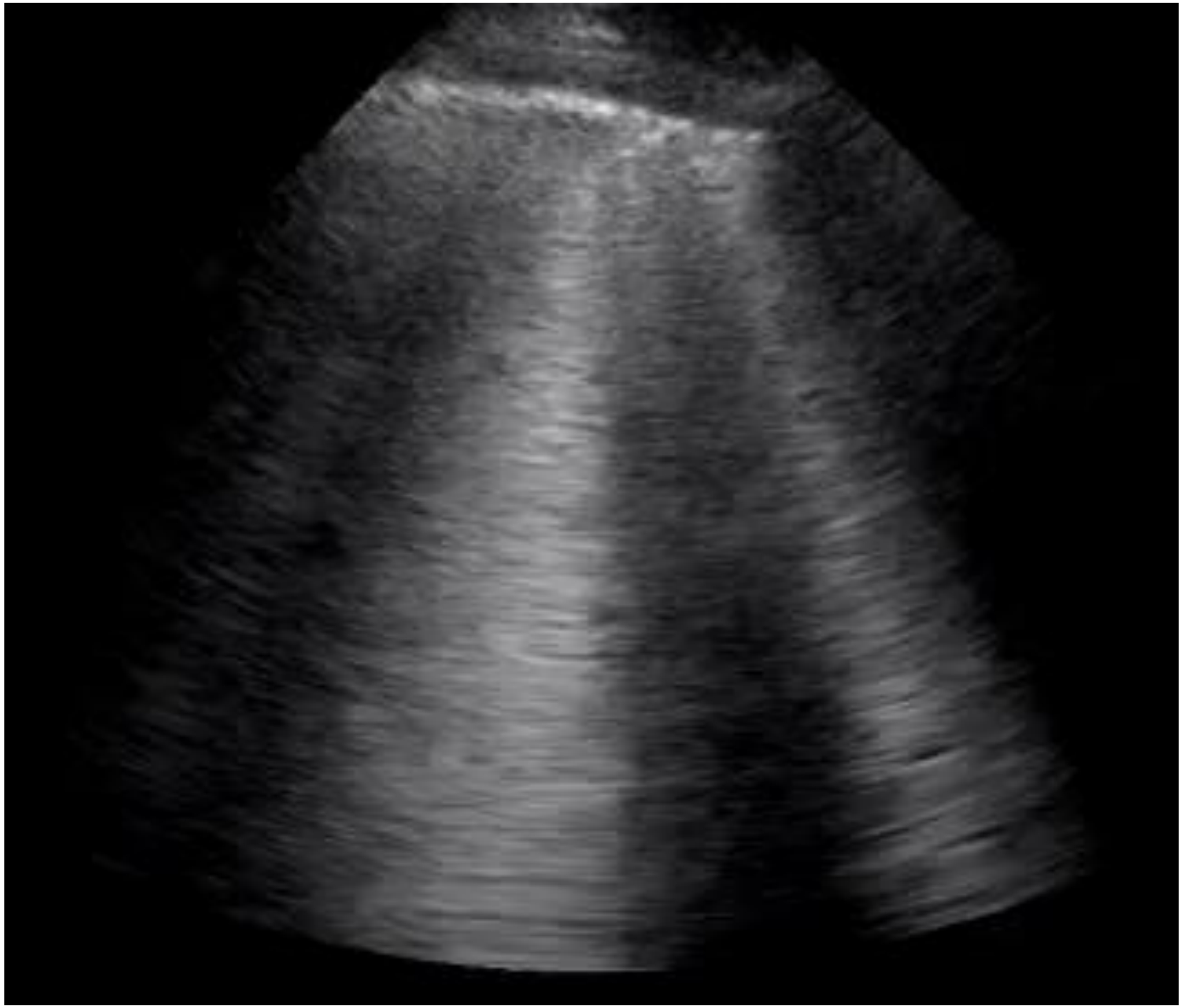


Oscillation → Resonance ↑ → Echo ↑ –> Ring down artifacts

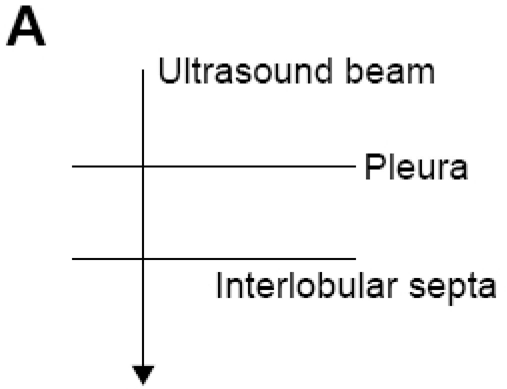
Reverberation – Short path, B-line, Ring-down

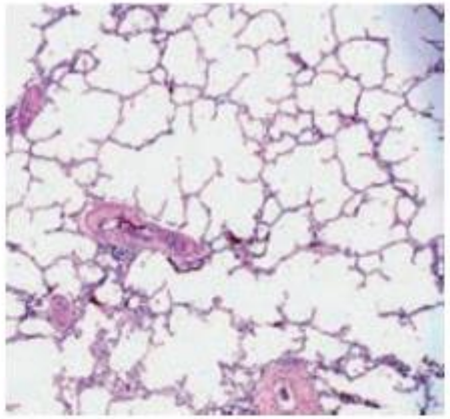


Reverberation –B-line, Ring-down

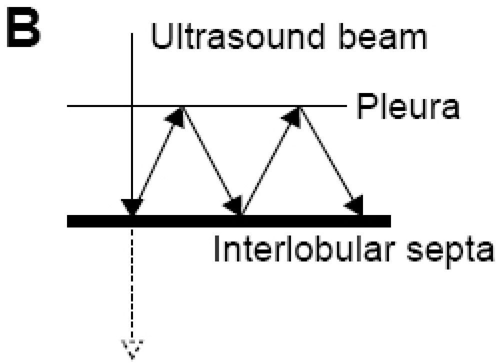


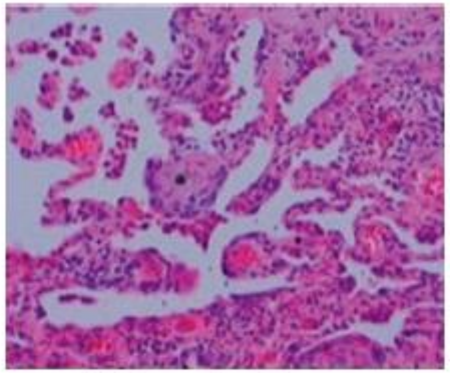
Reverberation – B-line, Ring-down




Normal lung

- Normal pleural and interlobular septa
  - Transmission. Not reverberate

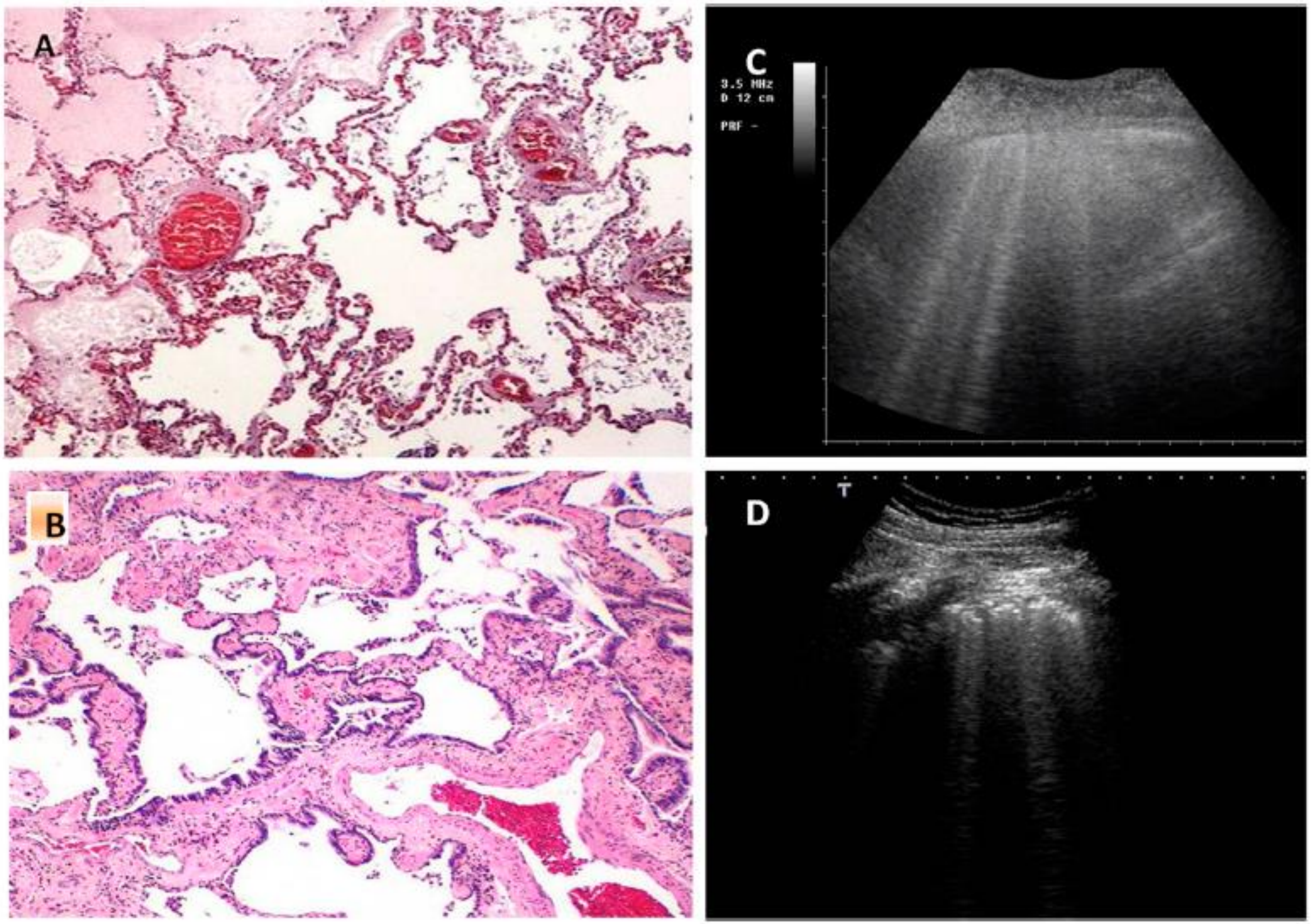



Fibrotic lung

- Thickened interlobular septa
  - Another high reflector (interlobular septa)
  - Reverberate

D. Manolescu et al. *Clin Interv Aging*. 2018;13:437-449

Reverberation – B-line, Ring-down



Countable, bilateral, homogenous

Subpleural fragmentation, discrete,

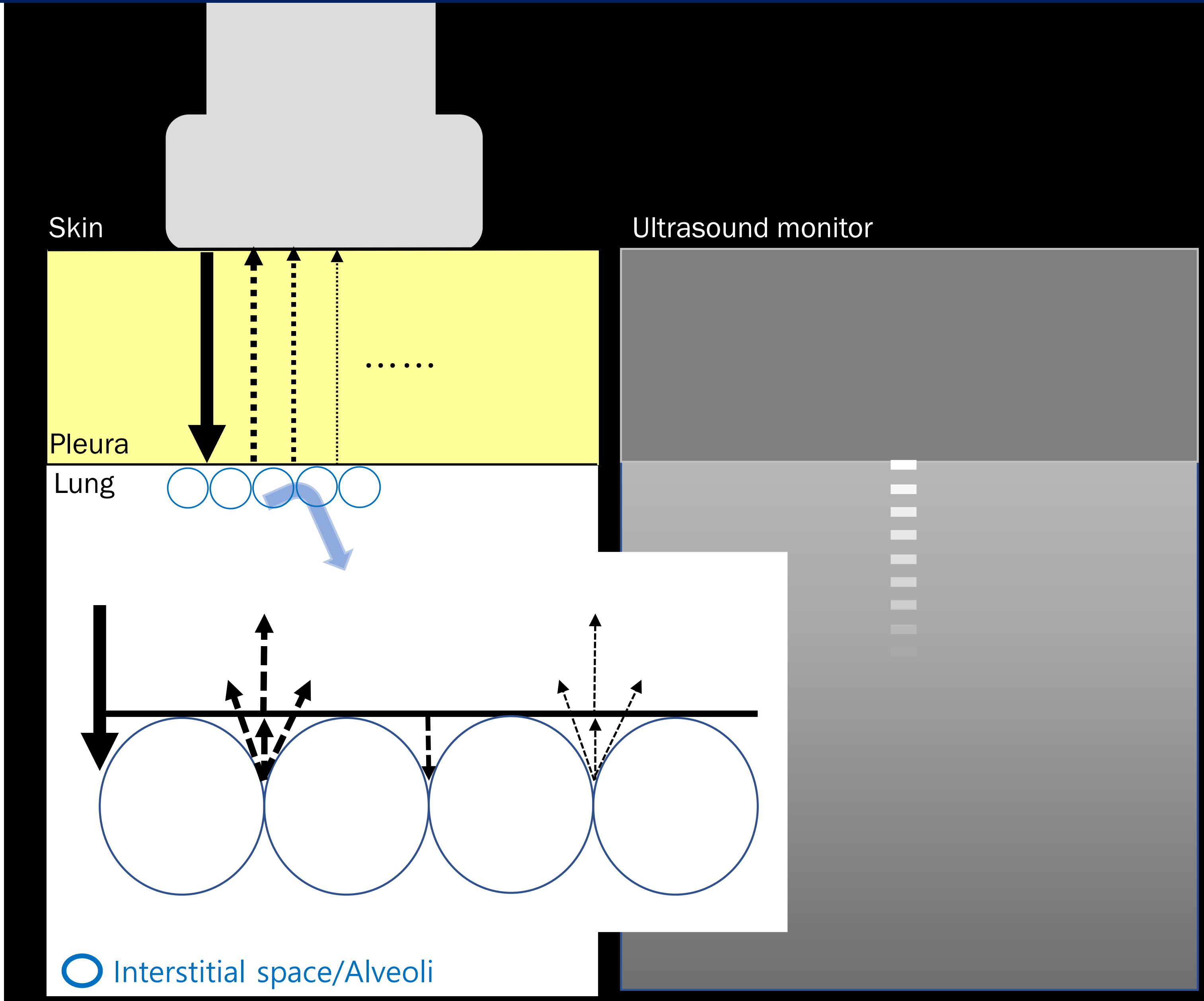
white-out

Gino Soldati et al. Appl. Sci. 2020, *10*, 1570 10

Reverberation – B-line, Ring-down

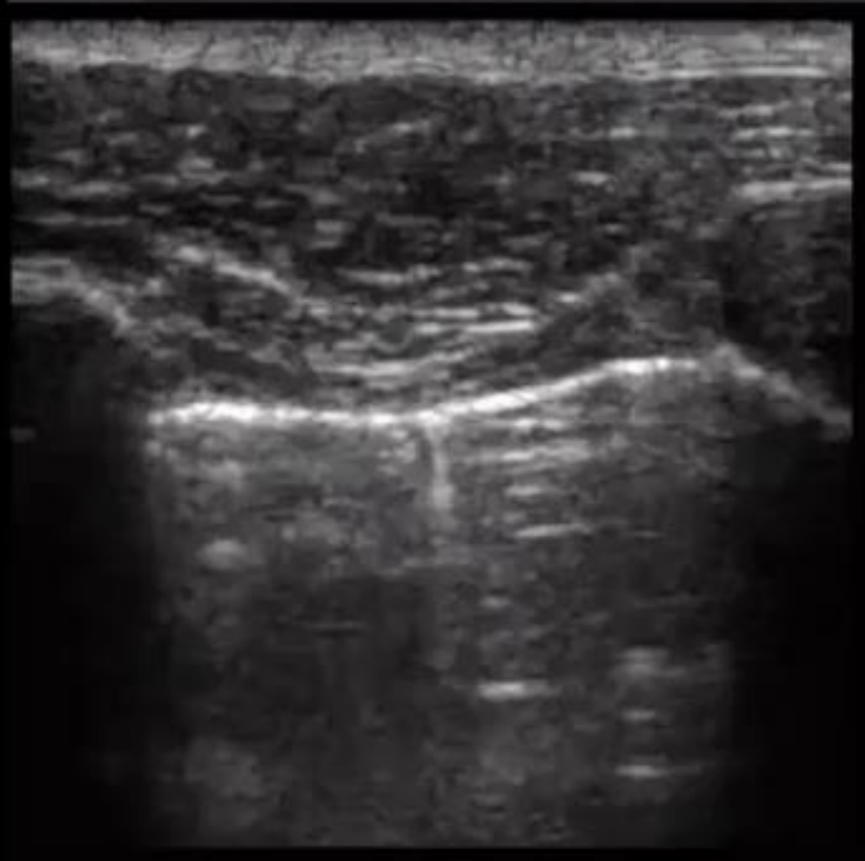
- Ring-down artifact (B-line ≠ Comet tail artifact)
- Arising from pleura
- Hyperechoic
- Erasing A-line
- Moving with lung sliding
- e.g.) acute pulmonary edema, interstitial lung disease, ARDS, atypical pneumonia

Reverberation – Short path, Comet tail artifact



Comet-tail sign = intact of VPPI

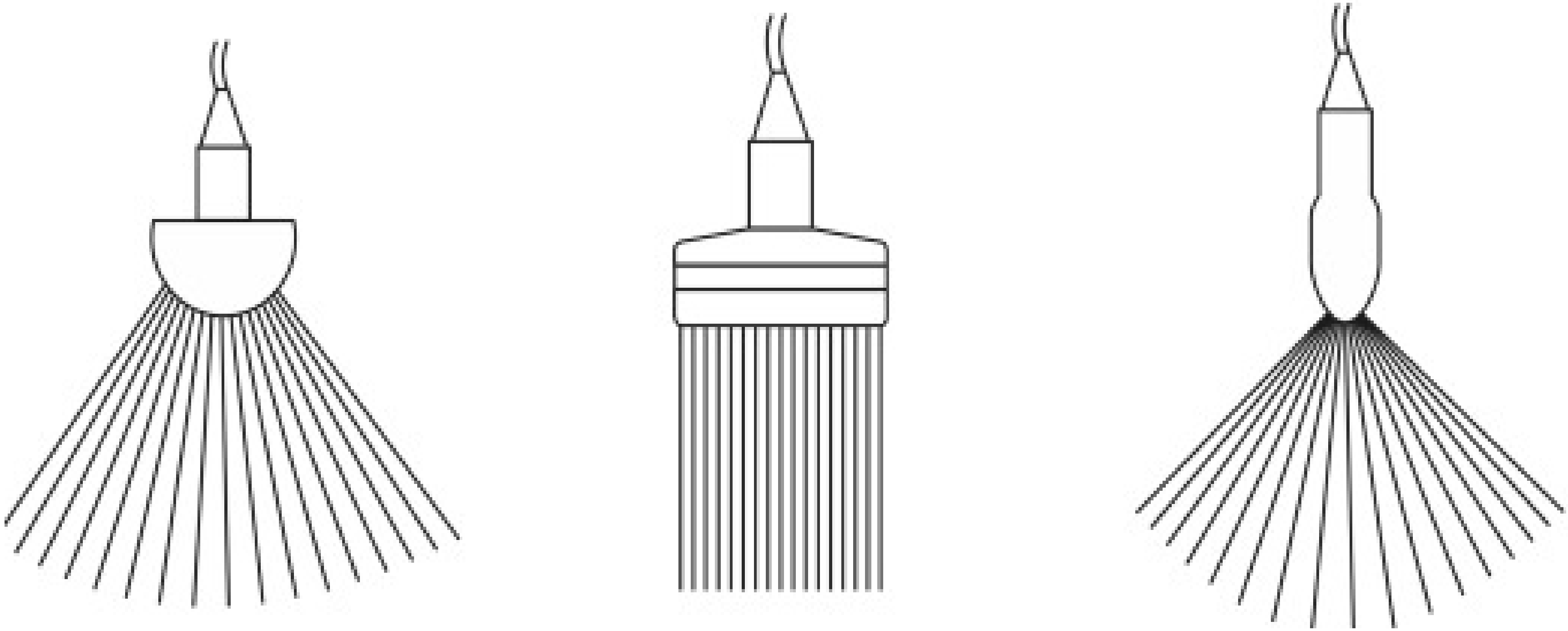
(no pneumothorax)



How to start the lung ultrasound?

Probe selection

- Complementary use is necessary



	Convex array	Linear array	Phased array
Frequency range	Higher (2-12 MHz)	Higher (8-15 MHz)	Lower (1-6 MHz)
Depth of imaging	Intermediate (2-6 cm)	Superficial (1-4 cm)	Deeper (4-8 cm)

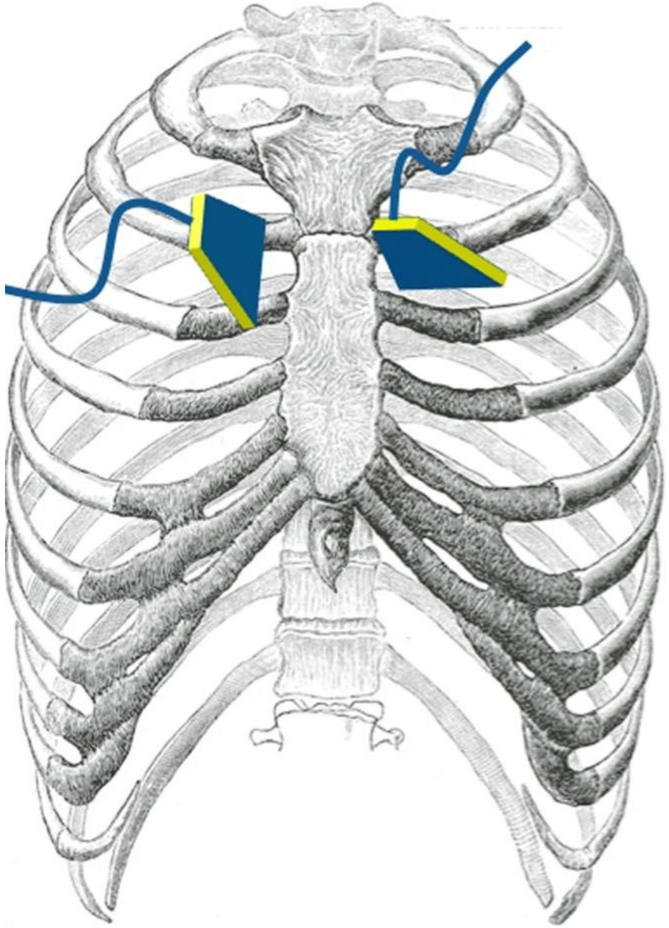
Moiyadi AV. World Neurosurg. 2016 Sep;93:81-93.

Scanning skills

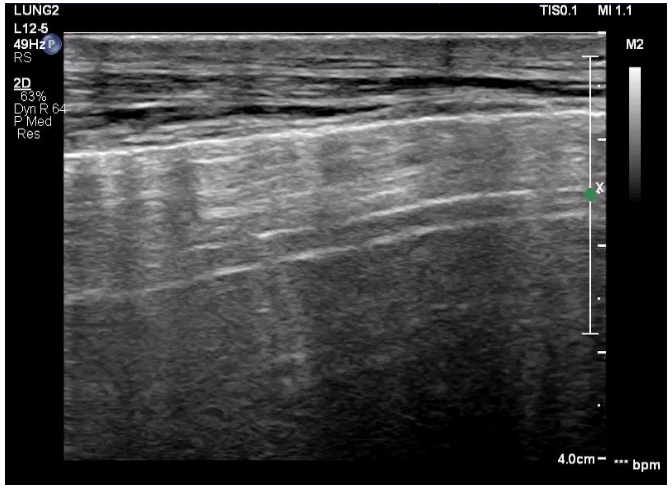
- Use preset for lung (or use abdominal set)
- Each point at least one whole respiration cycle (5-6s)
- Depth : convex or phased array (8-10 cm), linear (4-6cm)
- Gain : optimize visualization of the pleural line
- Focus : on the pleural line
- Patient position : supine, semi-recumbent, Semi-Fowler`s, prone
- Scanning point: BLUE, 8 zone, 12 zone etc

Longitudinal or transverse scan (oblique)?

Longitudinal scan



Transverse (or oblique) scan



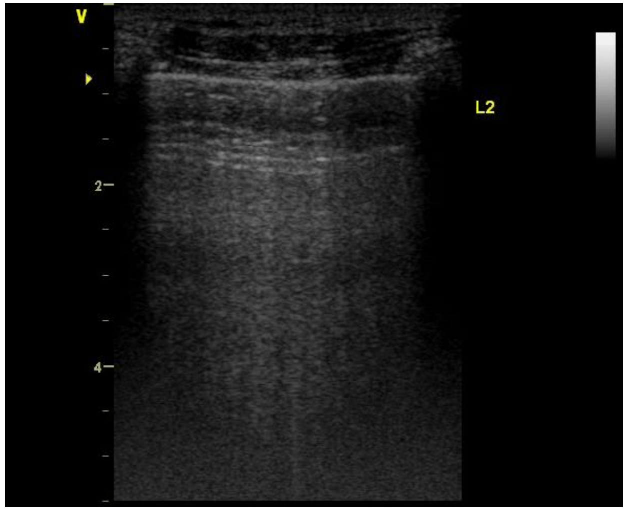
Tai Joon An. Data from Yeouido St. Mary`s Hospital
L Gargani et al. How I do it: Lung ultrasound. *Cardiovascular Ultrasound* Vol 12, 25 (2014)

What to look for in the lung ultrasound?

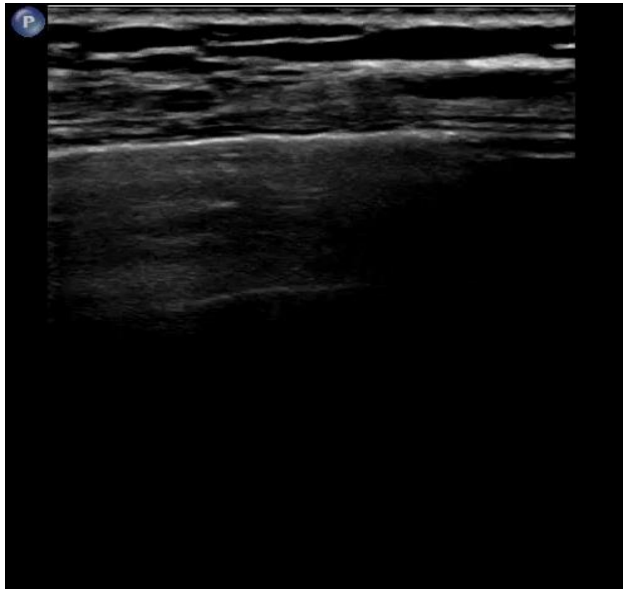
Lung sliding and A-line

- Lung sliding
  - Lung moves with the chest wall (passively)
  - At visceral–parietal pleura interface
  - Opposite direction movement
  - Shimmering appearance of the pleura
  - Lung sliding = intact VPPI
  - Curtain sign (at basal lateral)
  - Not to confuse with other hyperechoic line, such as intercostal muscle fascia

Lung sliding in anterior lung



Lung sliding in posterior-lateral area



F Mojoli et al. AJRCCM Vol 199. No 6, March, 2019

Lung sliding and A-line

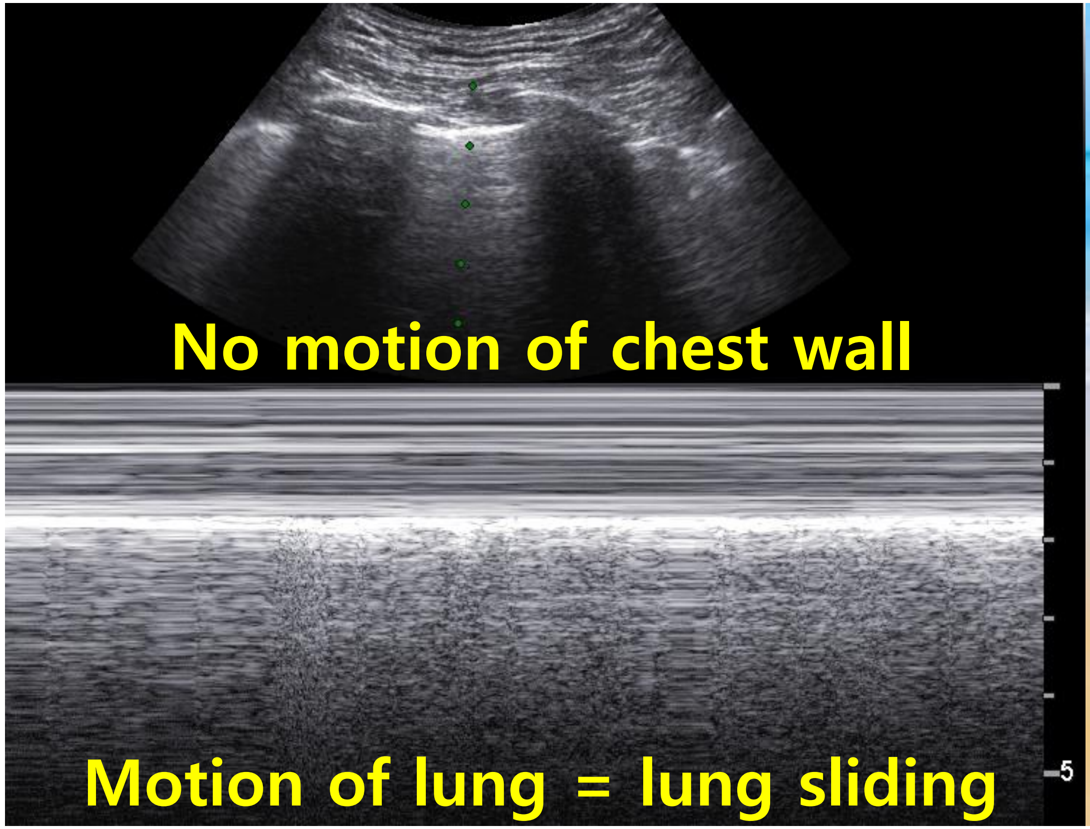
- A-line
  - Horizontal, echogenic long path reverberation artifact
  - Multiples of distance between probe and visceral-parietal pleural interface
  - Insonation of an aerated lung

- Lung sliding (+) + A-line (+)
  - Normal aerated, normal movement of lung

F Mojoli et al. AJRCCM Vol 199. No 6, March, 2019

Lung sliding (+) + A-line (+) in M-mode

- M-mode : motion mode
- Time trace movement of certain point
- Seashore sign

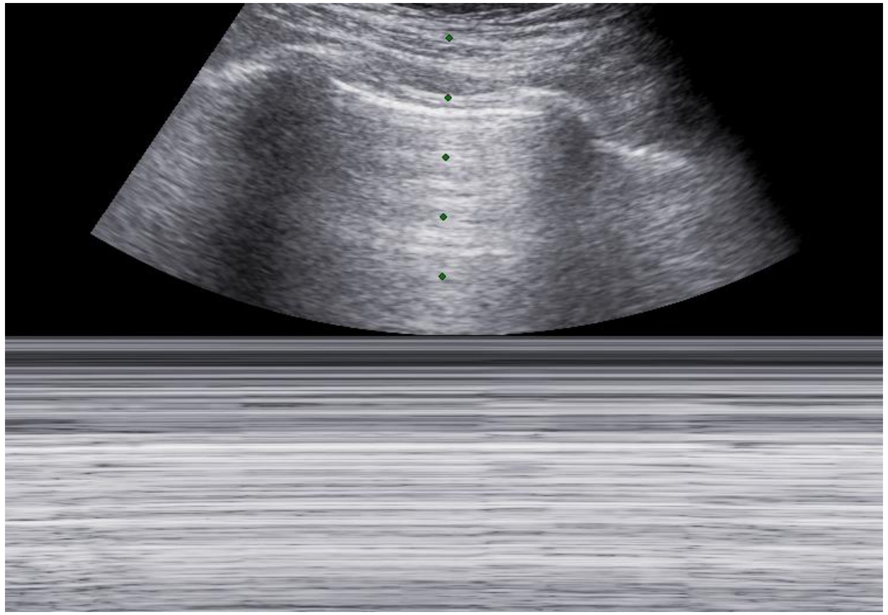


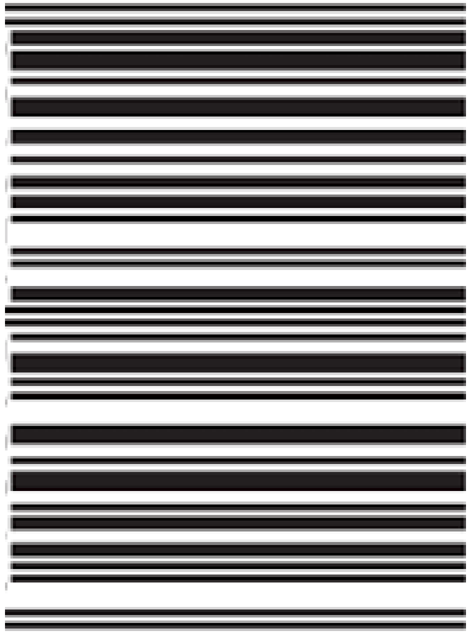
Lung sliding (-) and A-line (+)

- Lung sliding (-) + A-line (+)
  - No movement of pleura + much air beneath the pleura

→ suspect pneumothorax first

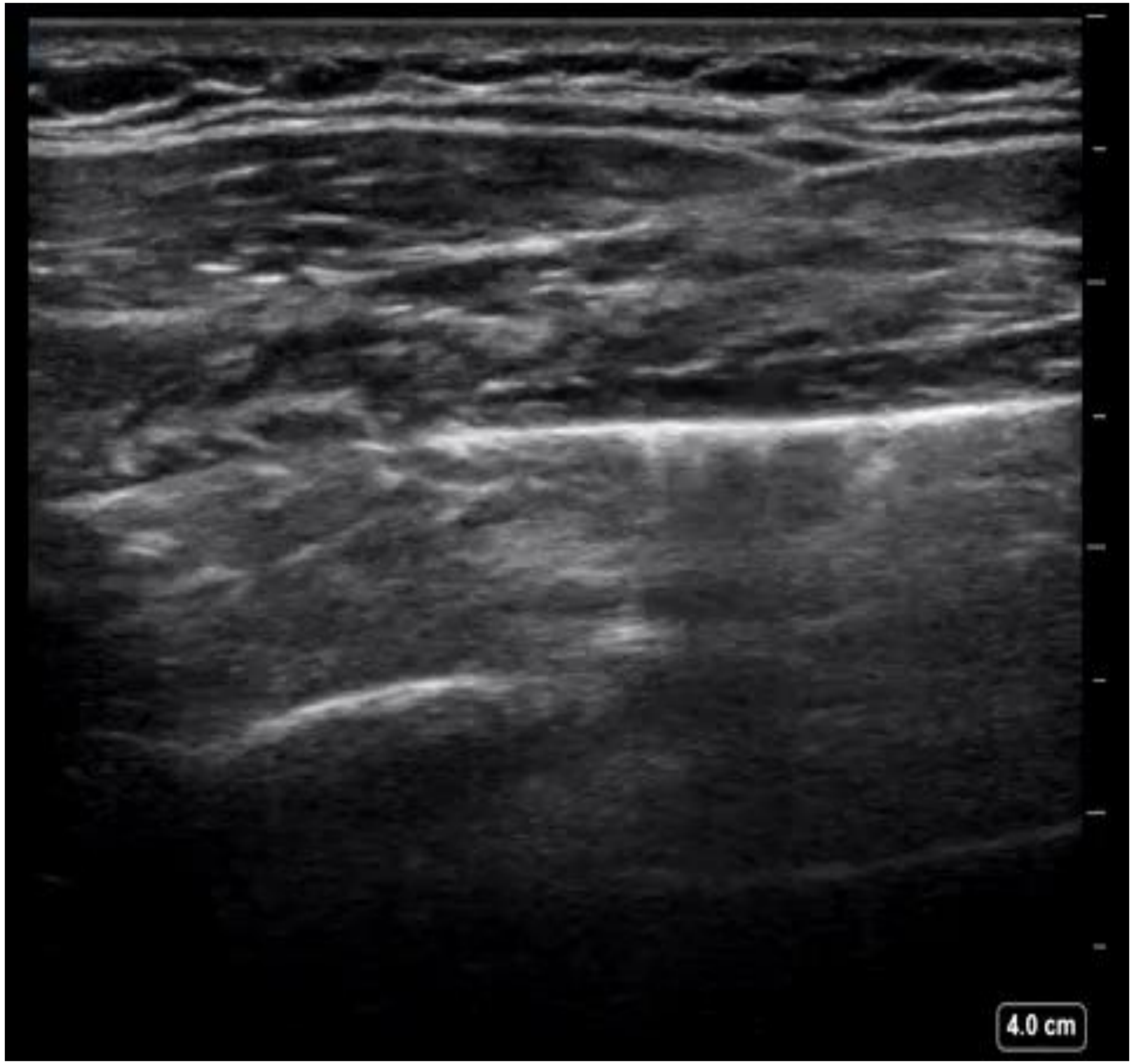
→ 1st chest M-mode and find lung point!





Lung point

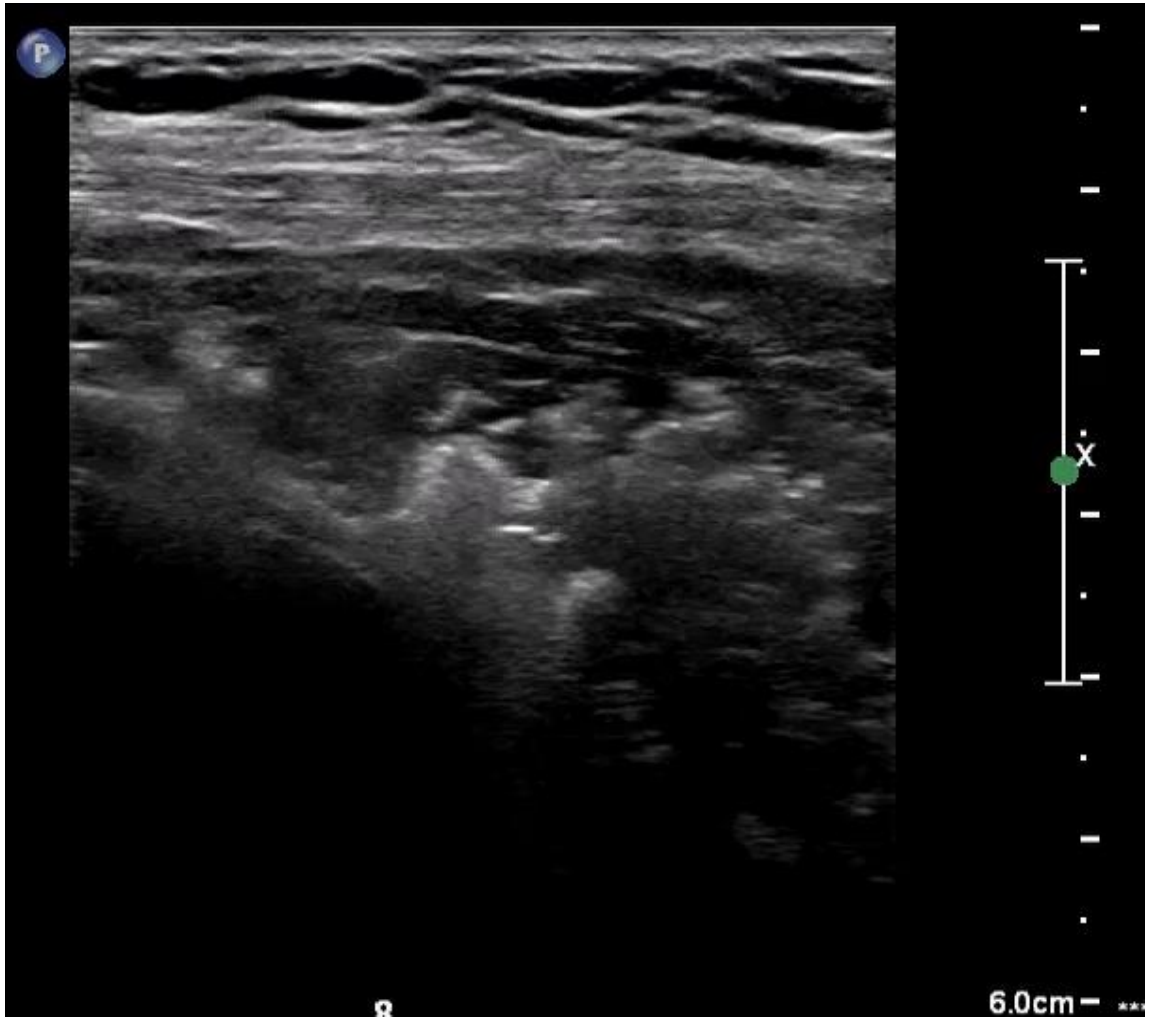
- Lung point: Lung sliding pattern change point
- Point at which visceral and parietal pleura meet
- Highly accurate for diagnosis of pneumothorax
- Dynamic point
  - Affected by body position, size of pneumothorax, and pleural adhesion
- Detected in both B-mode and M-mode



F Mojoli et al. AJRCCM Vol 199. No 6, March, 2019

Consolidation

- Parenchymal consolidation
  - Shred sign
    - Static lung consolidation
    - Subpleural hypoechoic lesion
    - Non-translobar consolidation



Consolidation

- Parenchymal consolidation
  - Tissue-like sign
    - Translobar consolidation
    - with or without air-bronchogram
    - Looks like liver

Tissue-like sign

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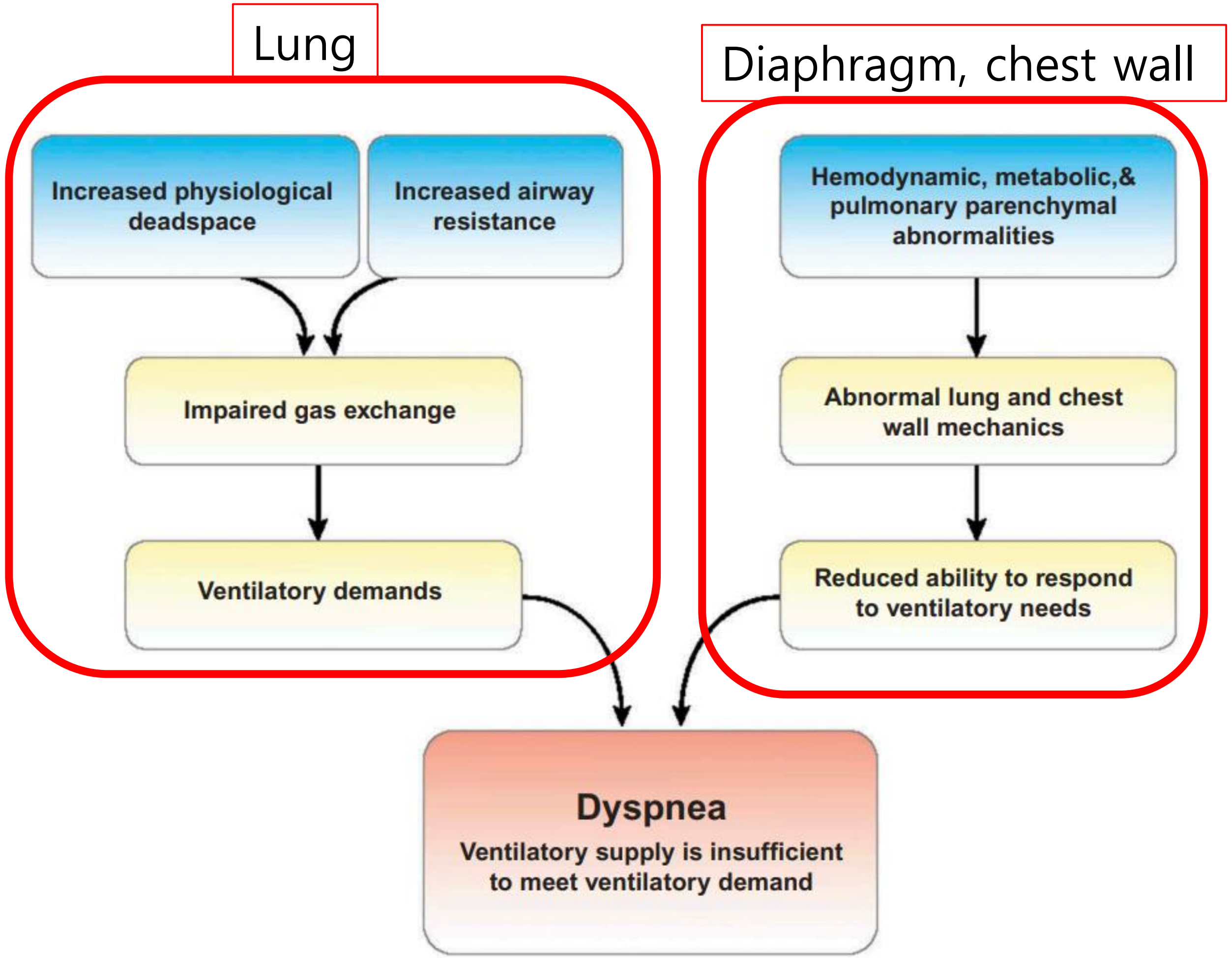
Advanced. Especially in COPD patients

Dyspnea and COPD

Table 2. Pulmonary and nonpulmonary causes of dyspnea [93].

Pulmonary	**Nonpulmonary (cardiac)**
COPD	Congestive heart failure
Asthma	Coronary artery disease
Interstitial lung disease	Cardiac arrhythmias
Bronchiectasis	Pericardial disease
Pulmonary hypertension	Valvular heart disease
Pleural effusion	
Malignancy (primary or metastasis)	
Nonpulmonary, noncardiac (less common)	
Thromboembolic disease	Anemia
Chest wall deformities (kyphoscoliosis)	Neuromuscular disorders (e.g. myasthenia gravis and amyotrophic lateral sclerosis)
Obesity (severe)	Psychogenic: general anxiety disorder and panic disorder
Metabolic conditions (uremia and acidosis)	Upper airway obstruction (laryngeal disease and tracheal stenosis)



POSTGRADUATE MEDICINE, 2017

Lung evaluation by LUS

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

- Observational study in university hospital for 4 yrs
- 301 consecutive adult patients with Acute Respiratory Failure in ICU

CHEST 2008; 134 : 117 – 125

Lung evaluation by LUS

Table 2—*Comprehensive Results**

Anterior Pattern	Bilateral-Predominant A Lines				Bilateral-Predominant B + Lines				Alveolar Consolidation				Predominant A Lines on One Side, and Predominant B + Lines on Other Side				A Lines
Lung sliding	+	−	+	−	+	+	−	−	+	+	−	−	+	+	−	−	−plus lung point
PLAPS	Yes	Yes	No	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Any
Pulmonary edema	2	0	0	0	54[1]	8	0	0	0	0	0	0	0	0	0	0	0
COPD	2	1	38	4	2	1	0	0	1	0	0	0	0	0	0	0	0
Asthma	1	0	33[1]	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pulmonary embolism	10[8]	0	10[9]	0	0	0	0	0	0	0	1[0]	0	0	0	0	0	0
Pneumothorax	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	8
Pneumonia	34	1	3	0	4	2	9	0	7	2	9	0	7	1	4	0	0
	A and A′ profile plus PLAPS		Normal profile, and A′ profile without PLAPS		B profile		B′ profile		C profile				A/B profile				Pneumothorax profile

CHEST 2008; 134 : 117 – 125

Lung evaluation by LUS

Table 3—*Combined Results**

Diagnoses	A Profile Plus PLAPS	Normal Profile, and A' Profile Without PLAPS	B Profile	B' Profile	C Profile	A/B Profile	Lung Point
Pulmonary edema	2	0	62^{1}	0	0	0	0
COPD or asthma	4	75^{1}	3	0	1	0	0
Pulmonary embolism	10^{8}	10^{9}	0	0	1^{0}	0	0
Pneumothorax	0	1	0	0	0	0	8
Pneumonia	35	3	6	9	18	12	0

*Exponents indicate No. of cases with venous thrombosis (datum without exponent means negative venous exploration). To simplify this Table, COPD and asthma are considered together; three columns in Table 2 were combined because analysis showed no loss in performance. One patient with pneumonia and the A' profile plus PLAPS was inserted in the A profile plus PLAPS column. The term *lung point* implies abolished anterior sliding associated with anterior A lines.

CHEST 2008; 134 : 117 – 125

Lung evaluation by LUS

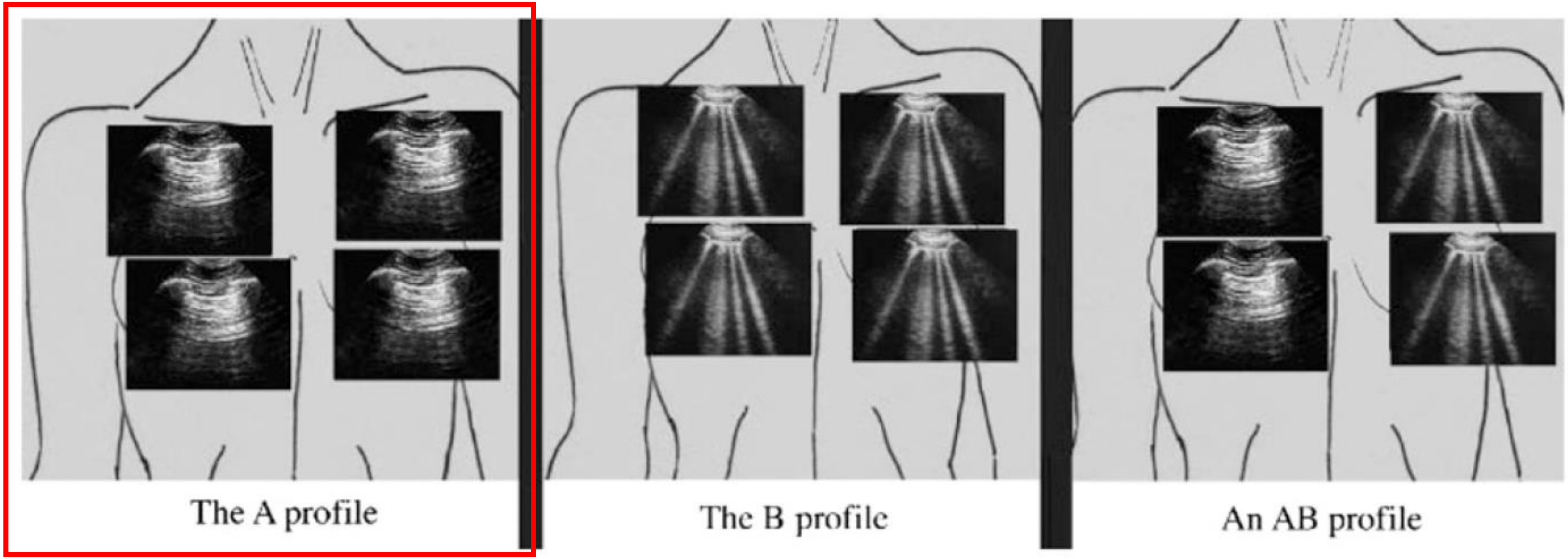
Table 4—*Accuracy of the Ultrasound Profiles**

Disease	Ultrasound Signs Used	Sensitivity, %	Specificity, %	Positive Predictive Value, %	Negative Predictive Value, %
Cardiogenic pulmonary edema	Diffuse bilateral anterior B + lines associated with lung sliding (B profile)	97 (62/64)	95 (187/196)	87 (62/71)	99 (187/189)
COPD or asthma	Predominant anterior A lines without PLAPS and with lung sliding (normal profile), or with absent lung sliding without lung point	89 (74/83)	97 (172/177)	93 (74/79)	95 (172/181)
Pulmonary embolism	Predominant anterior bilateral A lines plus venous thrombosis	81 (17/21)	99 (238/239)	94 (17/18)	98 (238/242)
Pneumothorax	Absent anterior lung sliding, absent anterior B lines and present lung point	88 (8/9)	100 (251/251)	100 (8/8)	99 (251/252)
Pneumonia	Diffuse bilateral anterior B + lines associated with abolished lung sliding (B' profile)	11 (9/83)	100 (177/177)	100 (9/9)	70 (177/251)
	Predominant anterior B + lines on one side, predominant anterior A lines on the other (A/B profile)	14.5 (12/83)	100 (177/177)	100 (12/12)	71.5 (177/248)
	Anterior alveolar consolidation (C profile)	21.5 (18/83)	99 (175/177)	90 (18/20)	73 (175/240)
	A profile plus PLAPS	42 (35/83)	96 (170/177)	83 (35/42)	78 (170/218)
	A profile plus PLAPS, B', A/B or C profile	89 (74/83)	94 (167/177)	88 (74/84)	95 (167/176)

*Data in parenthesis indicate No. of patients (total).

CHEST 2008; 134 : 117 – 125

A-profile for COPD/Asthma



CHEST 2008; 134 : 117 – 125

LUS: BLUE protocol

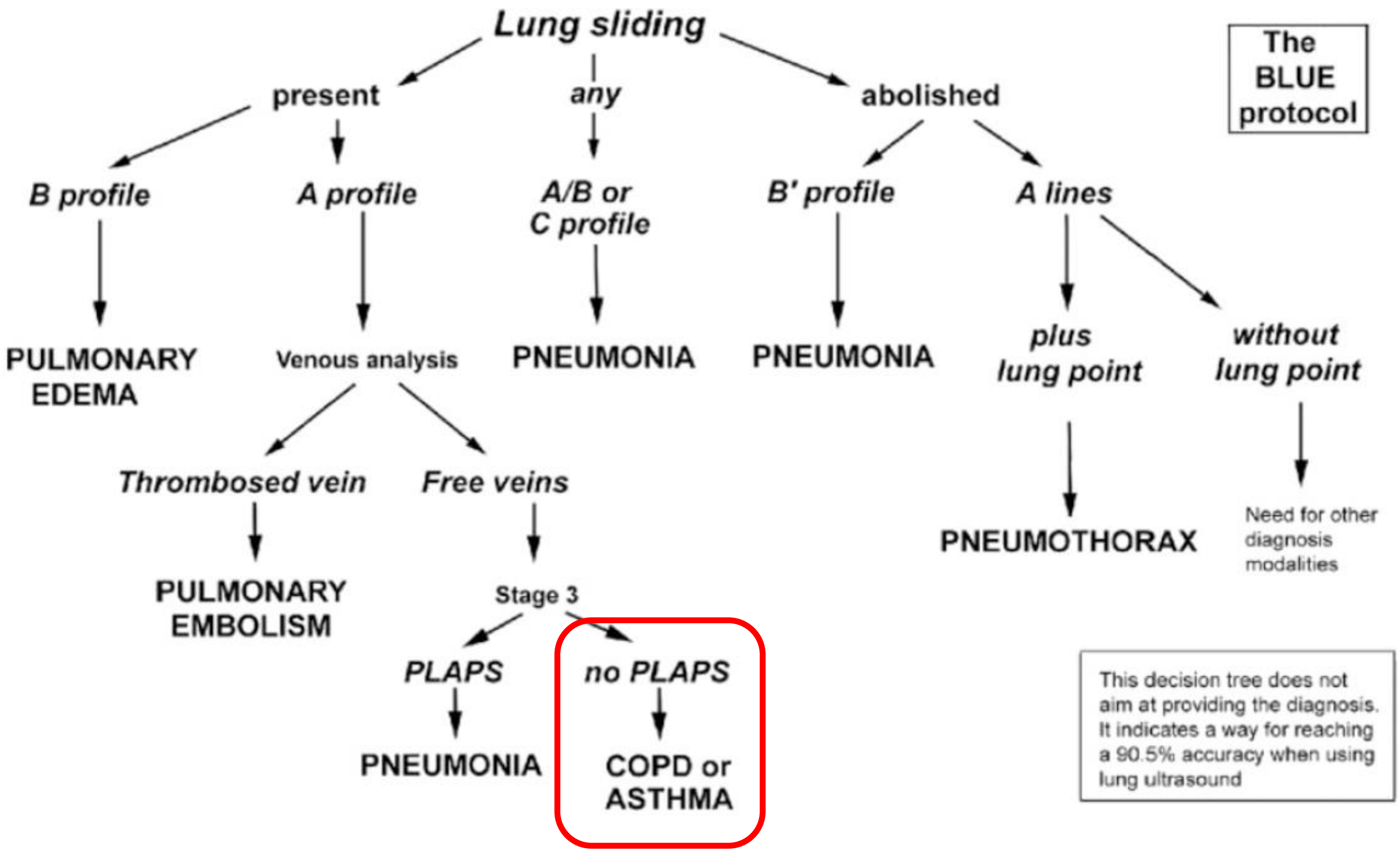


FIGURE 7. A decision tree utilizing lung ultrasonography to guide diagnosis of severe dyspnea.

Modification from BLUE

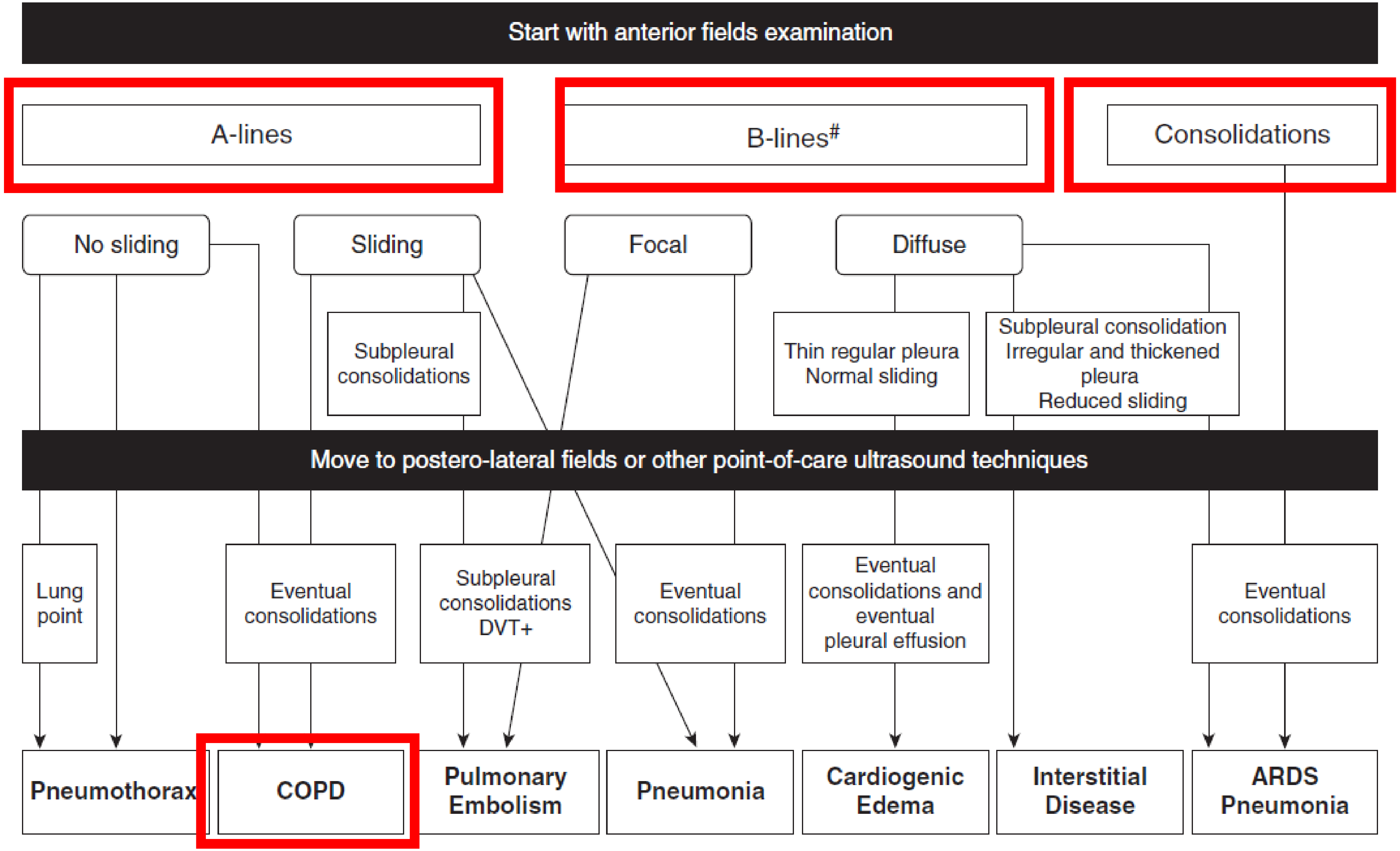


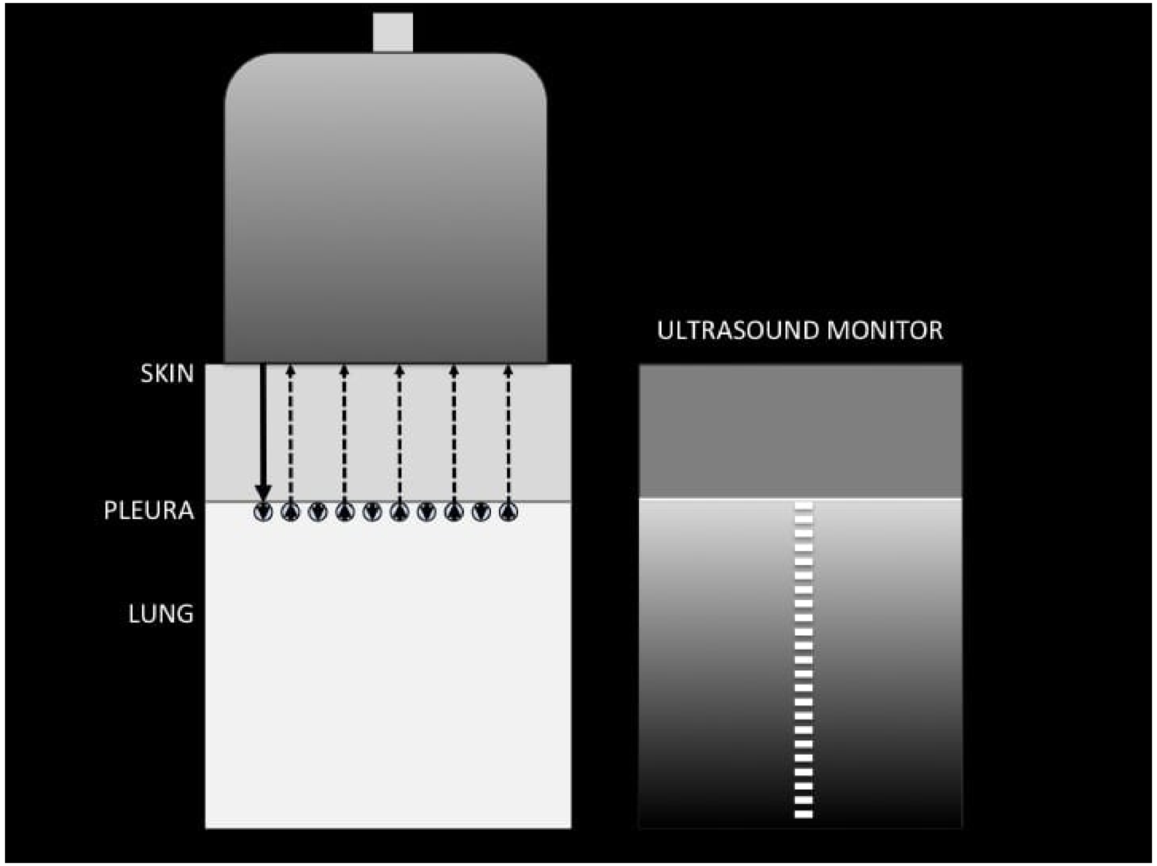
Figure 4. A proposal for a systematic diagnostic approach to acute respiratory failure based on literature findings (ARDS = acute respiratory distress syndrome; COPD = chronic pulmonary obstructive disease; DVT = deep venous thrombosis). #At least three B-lines per scan.

Mojoli et al. AJRCCM Vol 199. No 6, March, 2019

What about B-line in COPD?

Concepts of B-line

- B-line = Reverberations (Short path, B-line)



Recent proposal of diagnosis

CONCISE CLINICAL REVIEW

Lung Ultrasound for Critically Ill Patients

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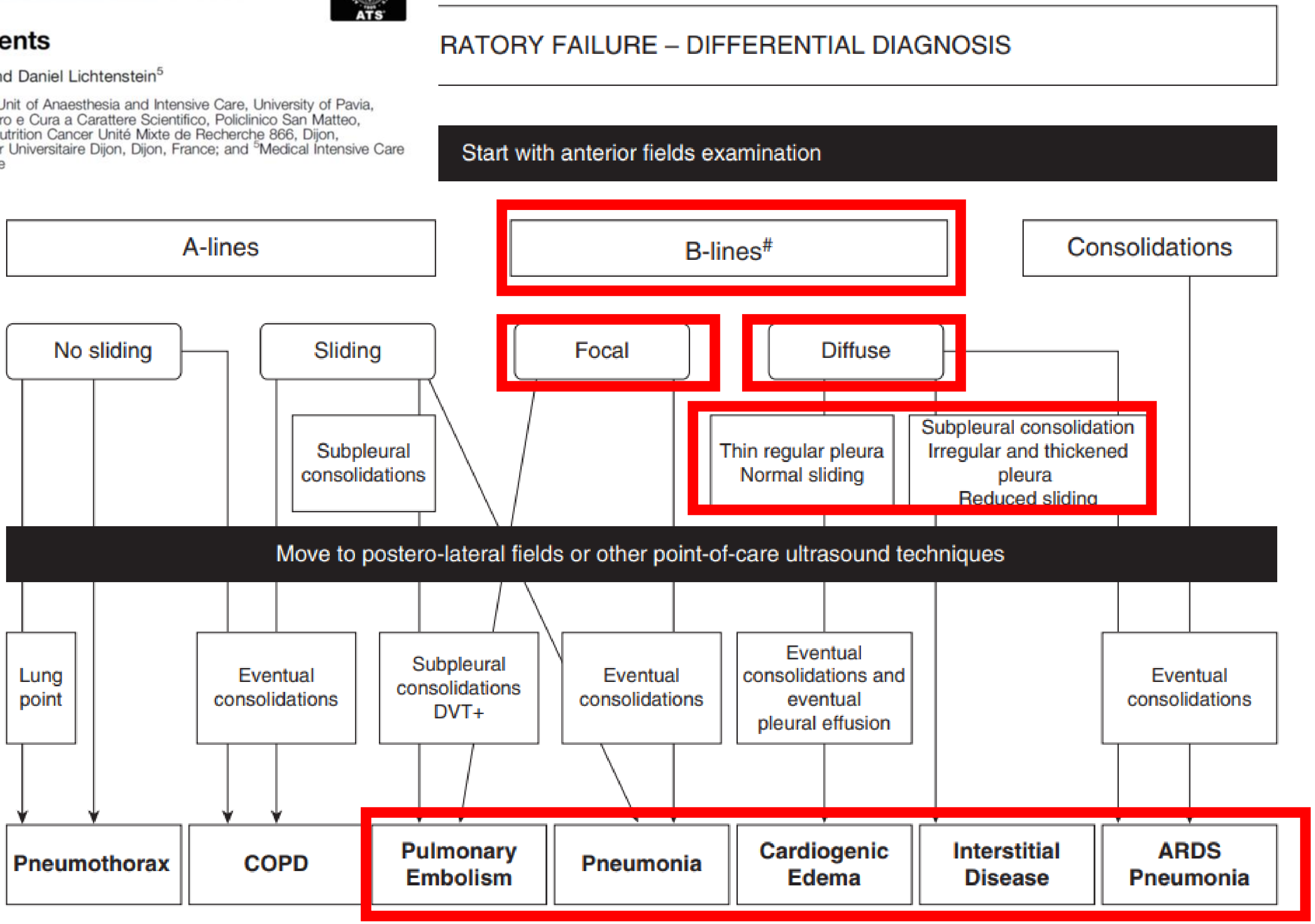
ORCID ID: 0000-0002-6031-6336 (F.M.).



AJRCCM Vol 199. No 6, March, 2019

Description of B-line: more details

A maximum of 2 B-lines per scan can be visualized in healthy lung	Normal lung (4, 18)
They originate from the visceral pleura	Rule out pneumothorax (sensitivity, 100%; specificity, 60.0%; negative predictive value, 100%) (10)
B-pattern ("lung rockets"): ⩾3 B-lines per scan are visualized	Indicates interstitial syndrome (17) Allows differential diagnosis between COPD exacerbation and cardiogenic edema (sensitivity, 100%; specificity, 92.0%) (9)
B-line distribution allows distinguishing specific diseases (4, 31):	
Focal B-pattern	Depending on the clinical context, it may correspond to pneumonia, atelectasis, lung contusion, pulmonary embolism, pleural disease, or neoplasia (4, 31)

AJRCCM Vol 199. No 6, March, 2019

Description of B-line: more details

Diffuse B-pattern at least 2 region per hemithorax
+

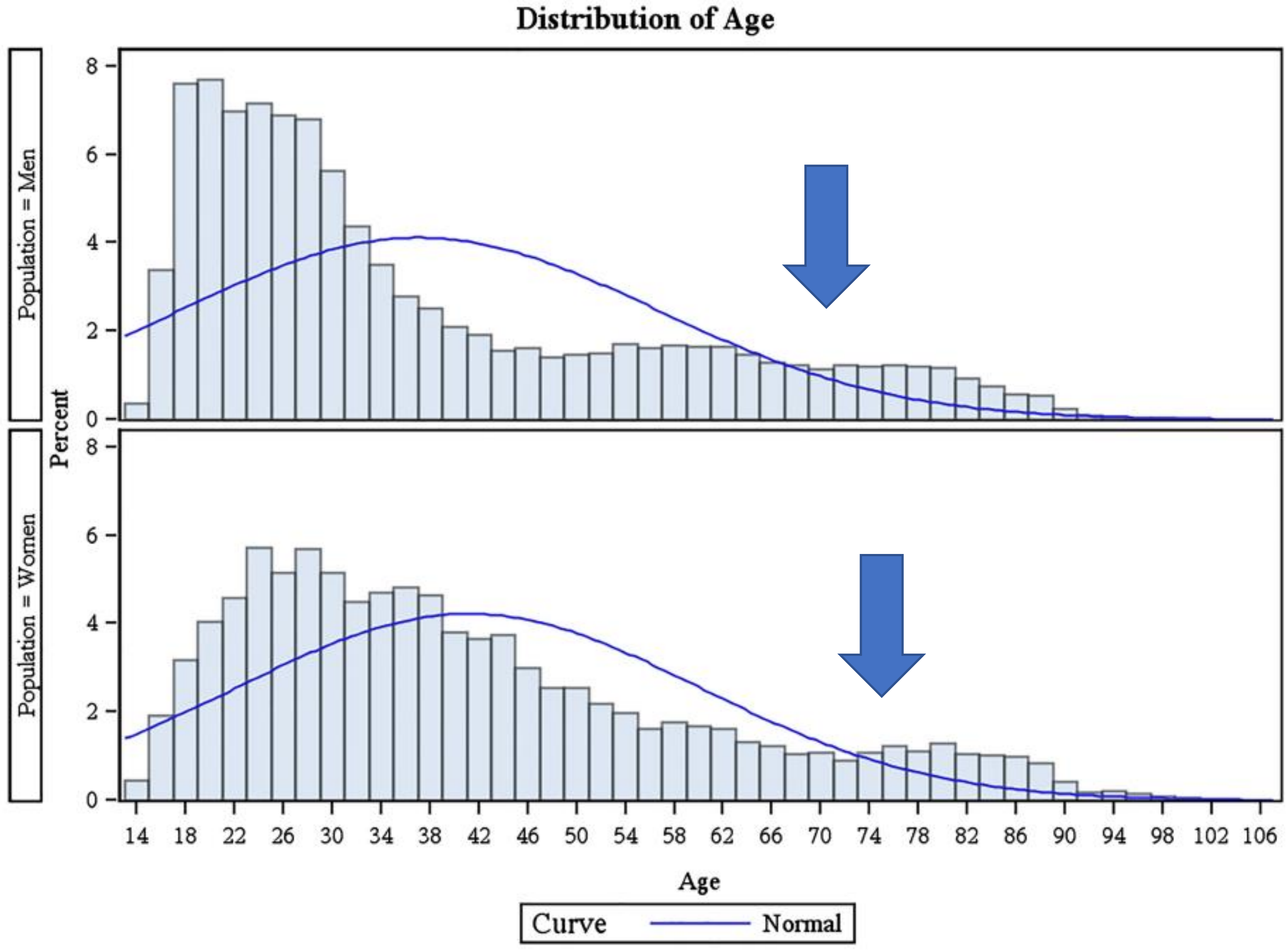
1) Homogenous distribution,
regular and thin pleura,
normal sliding,
± eventual bilateral pleural effusion

→ Cardiogenic edema

AJRCCM Vol 199. No 6, March, 2019

Pneumothorax in COPD

Incidence of spontaneous pneumothorax is higher in COPD



Bobbio A, et al. Thorax 2015;70:653–658

"This typically reflects the peak of incidence of idiopathic pneumothorax observed in young **men** and the **peak of secondary pneumothorax**, mainly related to underlying chronic lung diseases (**mostly COPD**). Among **women**, the first peak appears to be delayed and incidence remains stable up to 40 years. Similar to men, a second peak is observed around 60 years (although to a lesser extent than in men), probably also due to COPD-related secondary pneumothorax.

Does management of pneumothorax is changed?

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JANUARY 30, 2020 VOL. 382 NO. 5

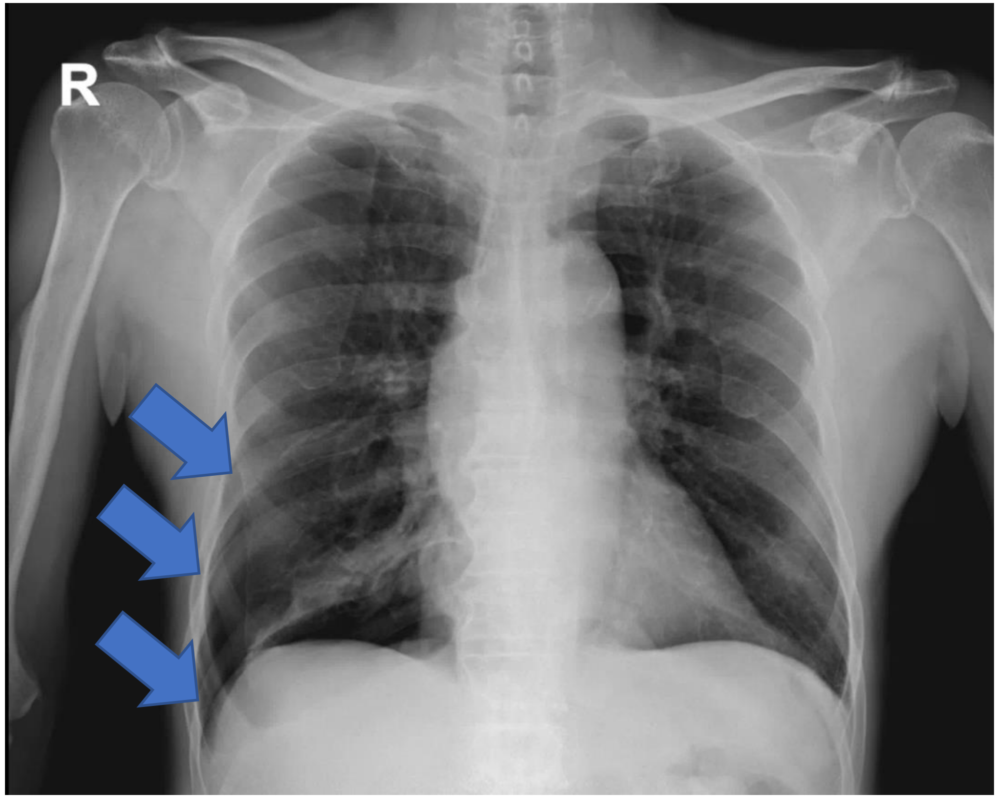
Conservative versus Interventional Treatment for Spontaneous Pneumothorax

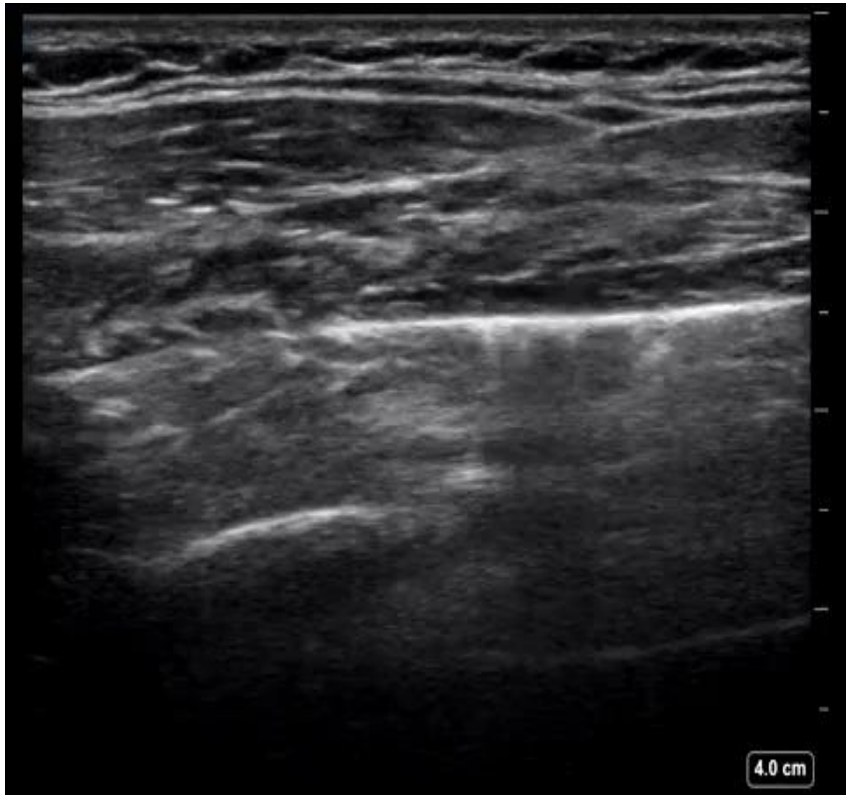
CONCLUSIONS

Although the primary outcome was not statistically robust to conservative assumptions about missing data, the trial provides modest evidence that conservative management of primary spontaneous pneumothorax was noninferior to interventional management, with a lower risk of serious adverse events. (Funded by the Emergency Medicine Foundation and others; PSP Australian New Zealand Clinical Trials Registry number, ACTRN12611000184976.)

How about secondary pneumothorax in COPD?

Male, Emphysema, patients, visits for OPD d/t mild dyspnea

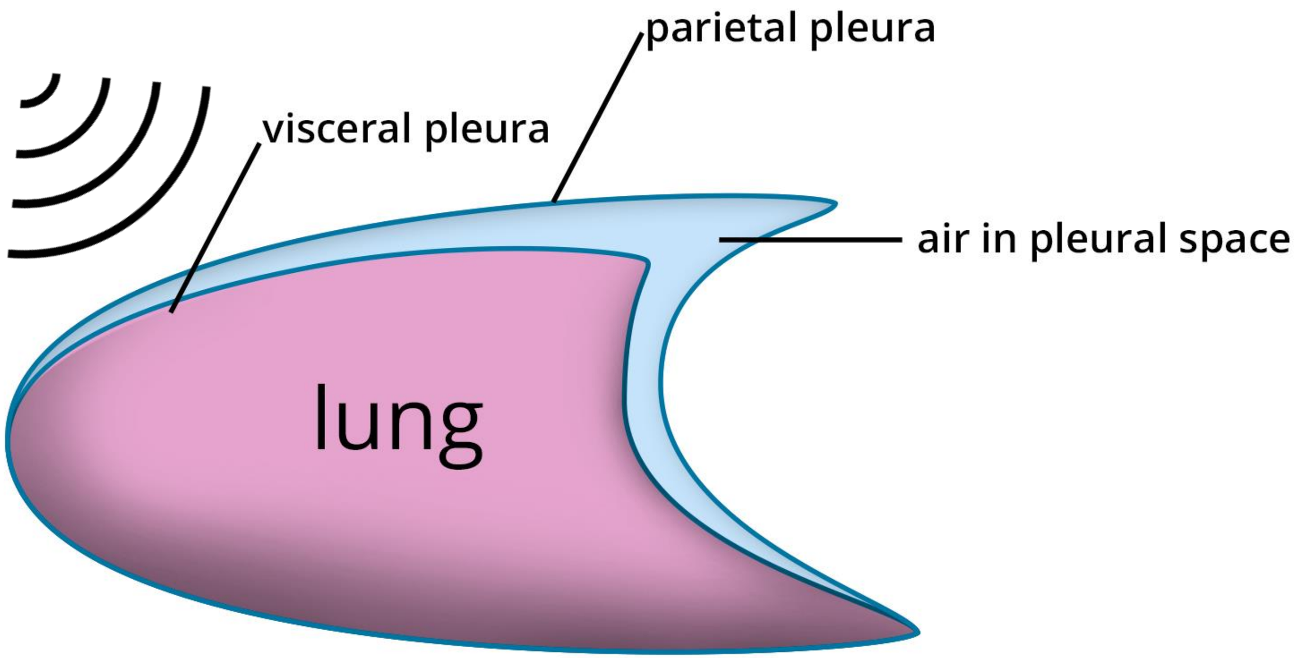




Daily LUS by mapping for lung points + high fraction O2 → improved without CTD

→ possible case of treating pneumothorax in COPD patients without CTD

Pneumothorax detection by LUS



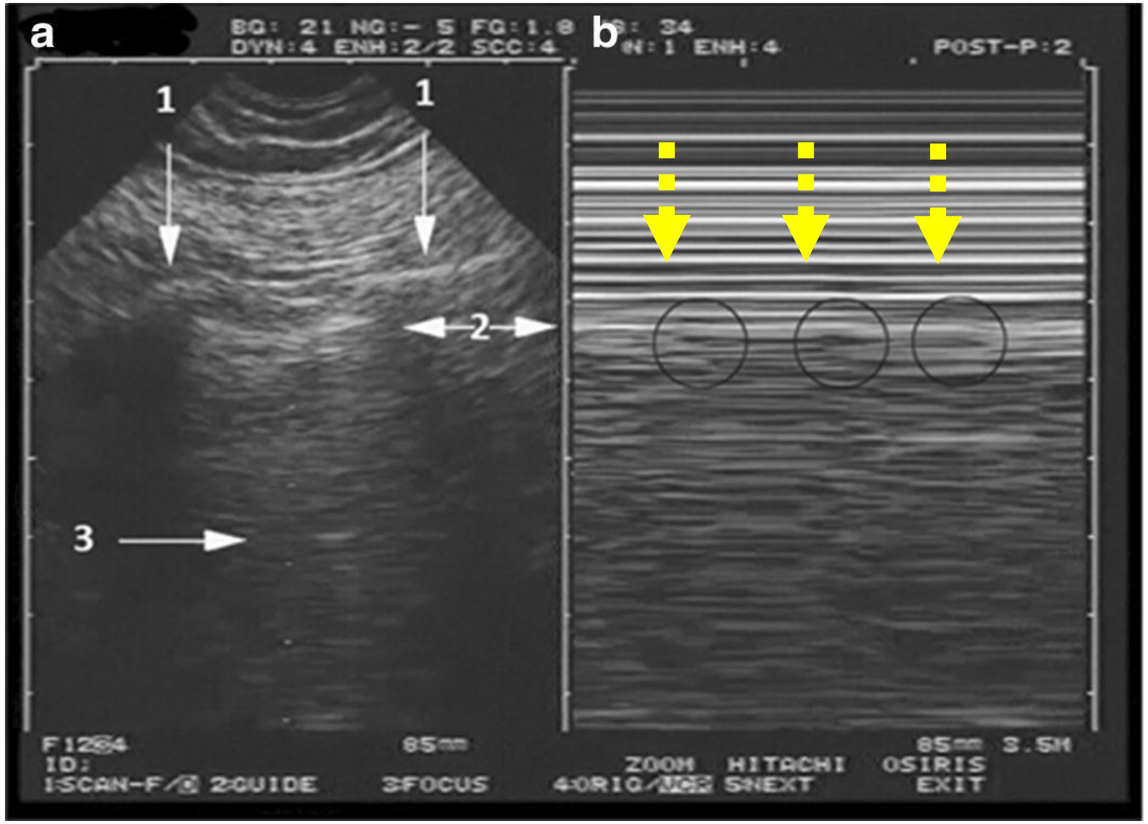
No movement of lung
Air filled space

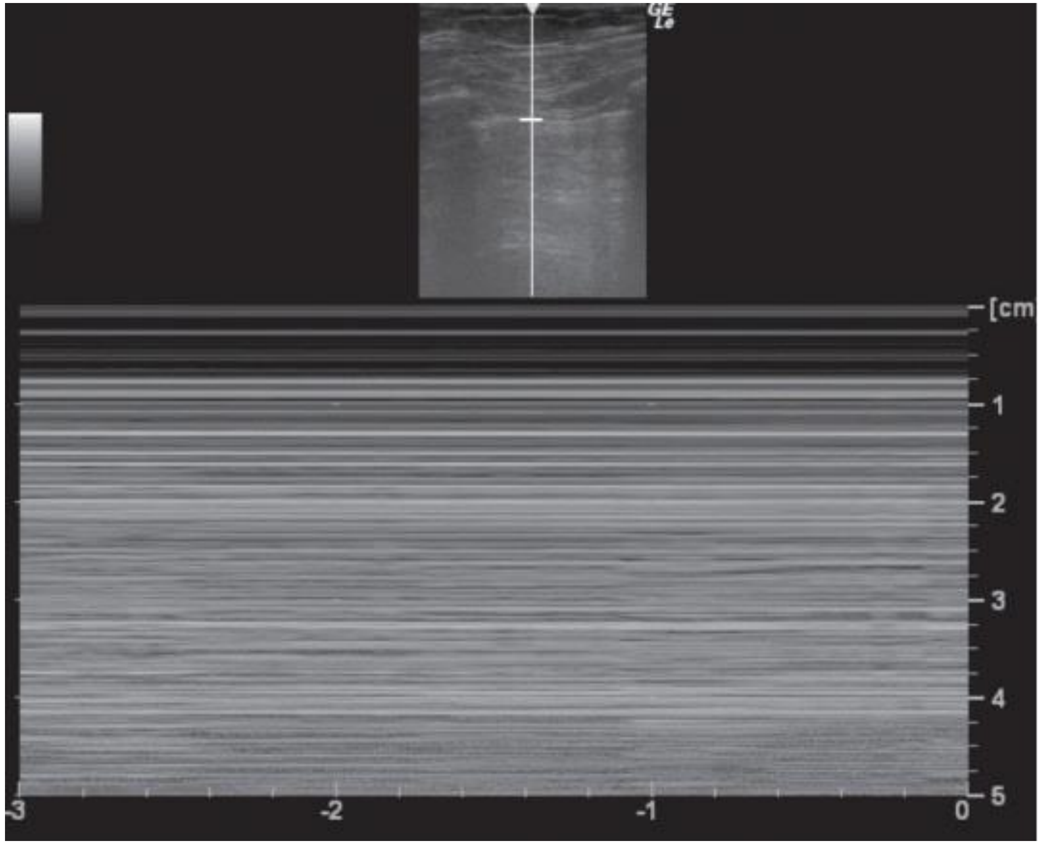
→

No lung sliding
A-line

Case courtesy of Dr Henry Knipe, Radiopaedia.org, rID: 31381

Why M-mode findings are not enough for pneumothorax?

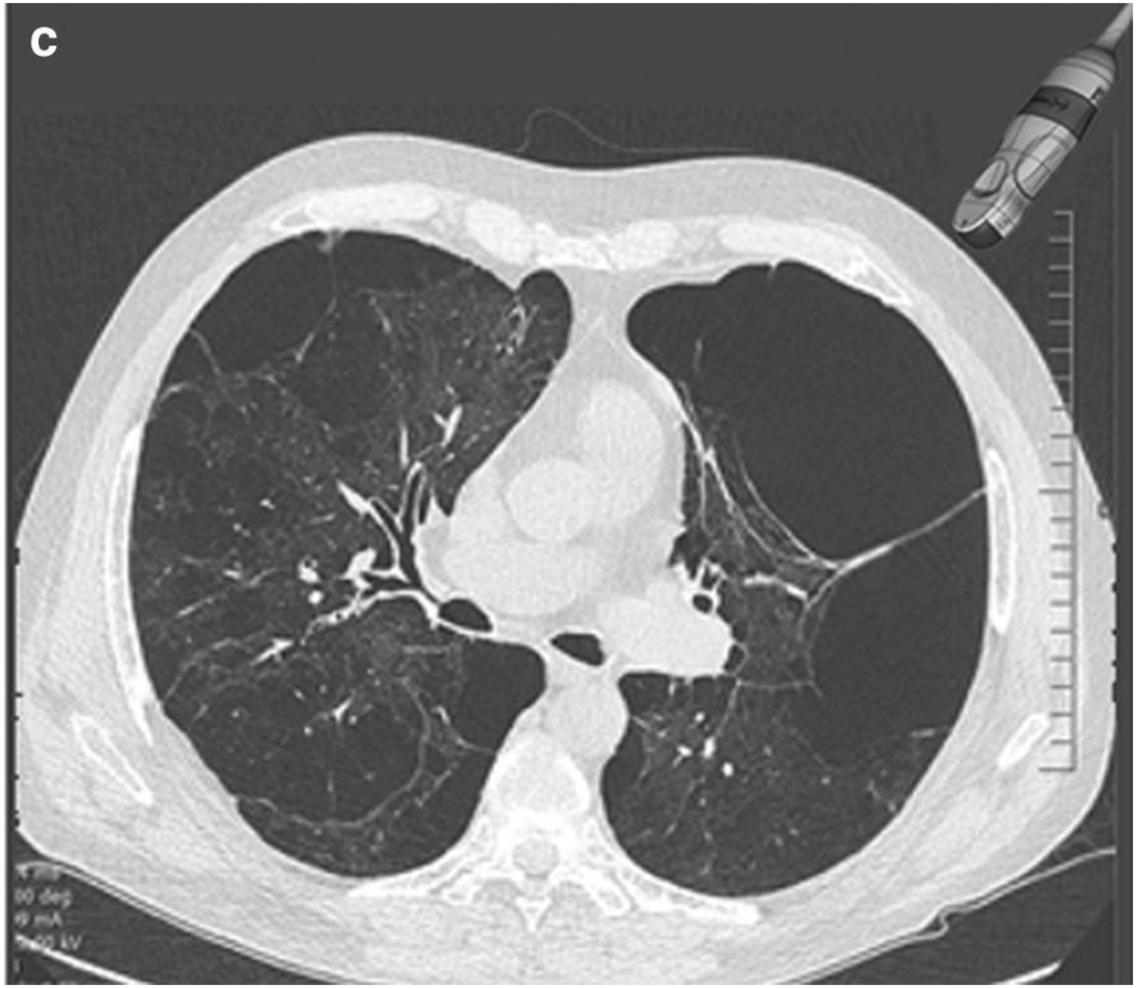




No lung sliding → Pneumothorax?

Lichtenstein et al. Intensive Care Med 2019 May;45(5):690-691

Why M-mode findings are not enough for pneumothorax?



Large bullae
: usually not be seen in LUS

But if there is minimal lung sliding,
we can exclude pneumothorax.

Barcode sign is not always "pneumothorax".

Lichtenstein et al. Intensive Care Med 2019 May;45(5):690-691

Pneumothorax detection by LUS: Lung point – B-mode

- Lung point

= point of lung sliding pattern change

= point that visceral meet parietal pleura

: Highly accurate for diagnosis of *pneumothorax*

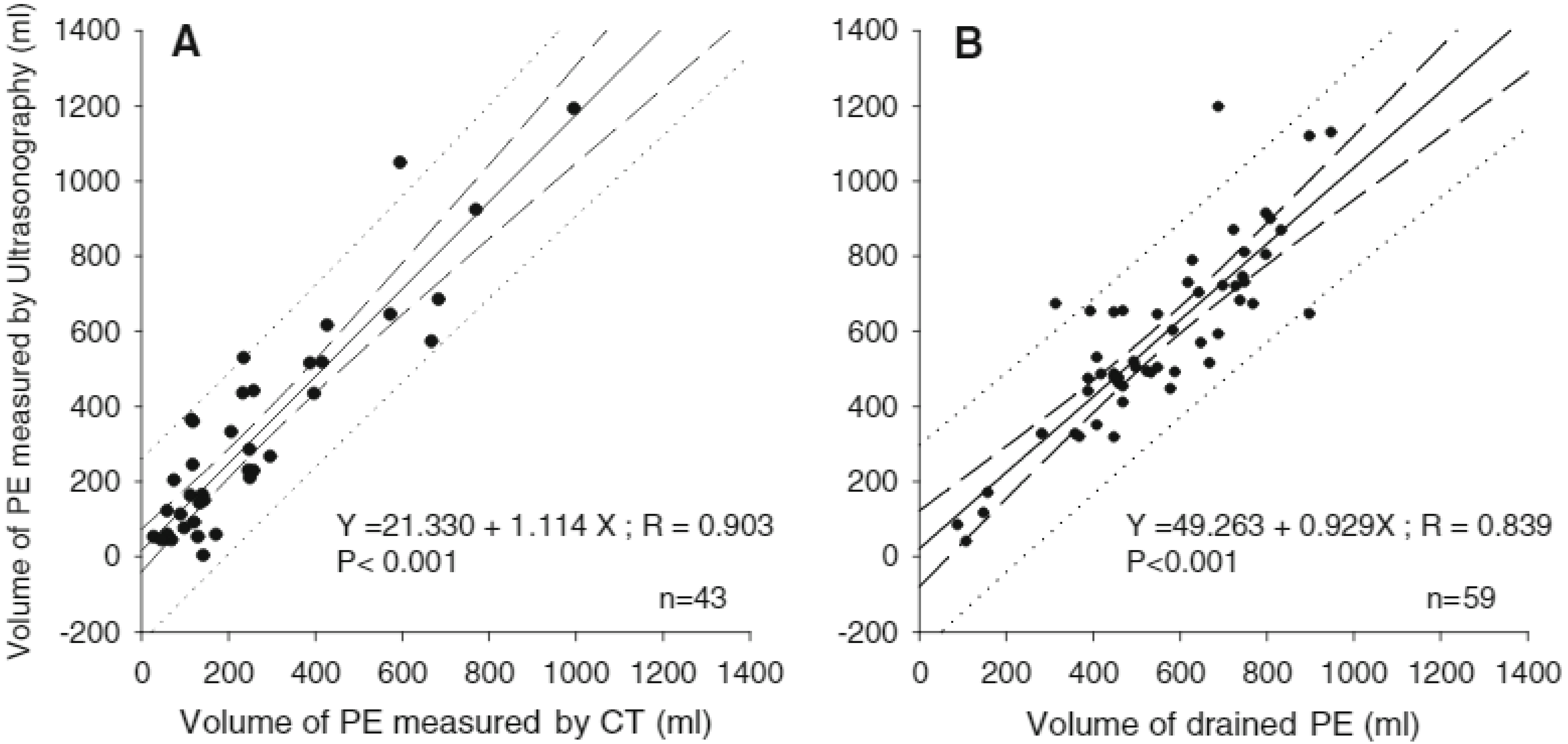
: Dynamic point affected by

body position, size of pneumothorax, and pleural adhesion

F Mojoli et al. AJRCCM Vol 199. No 6, March, 2019

Pleural effusion, Empyema in COPD

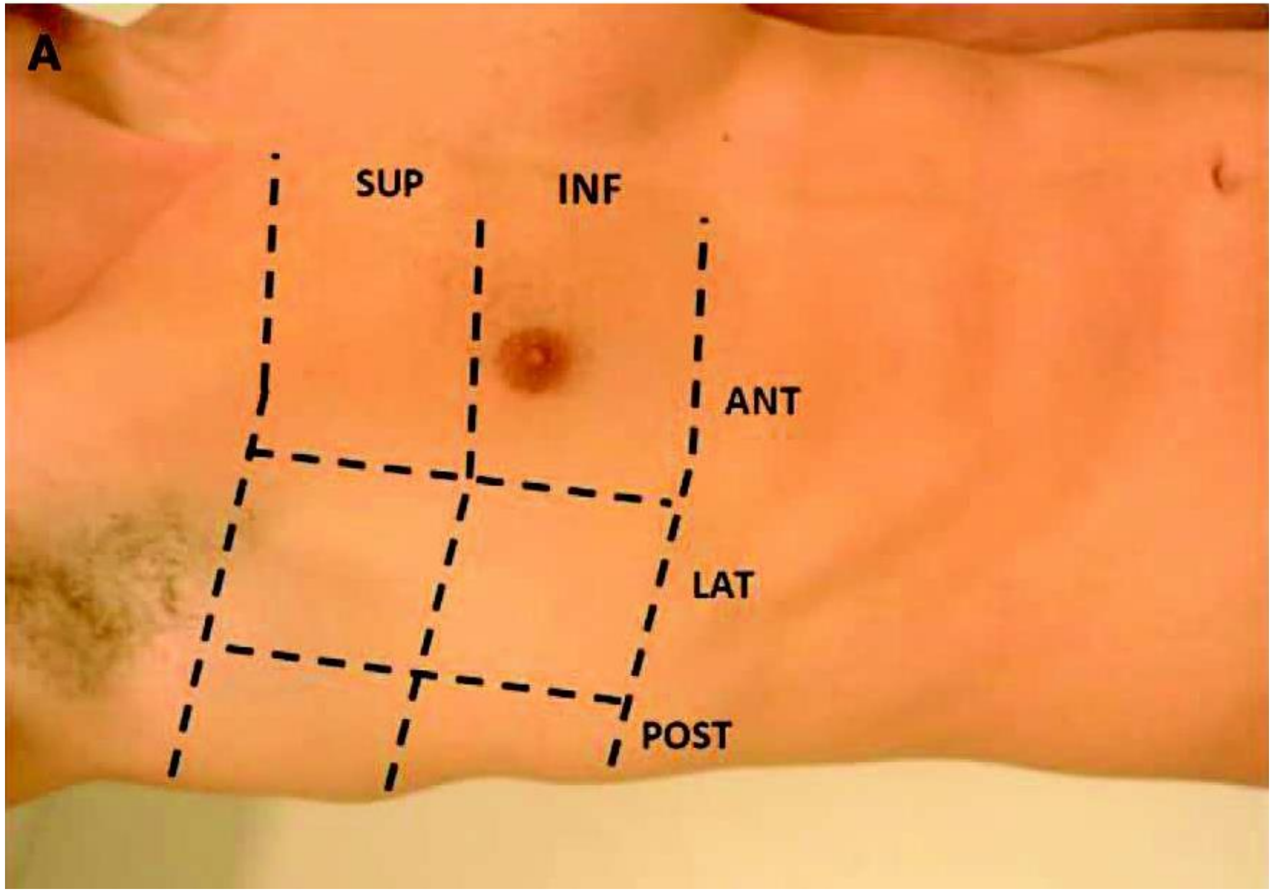
LUS is sensitive tools for pleural effusion



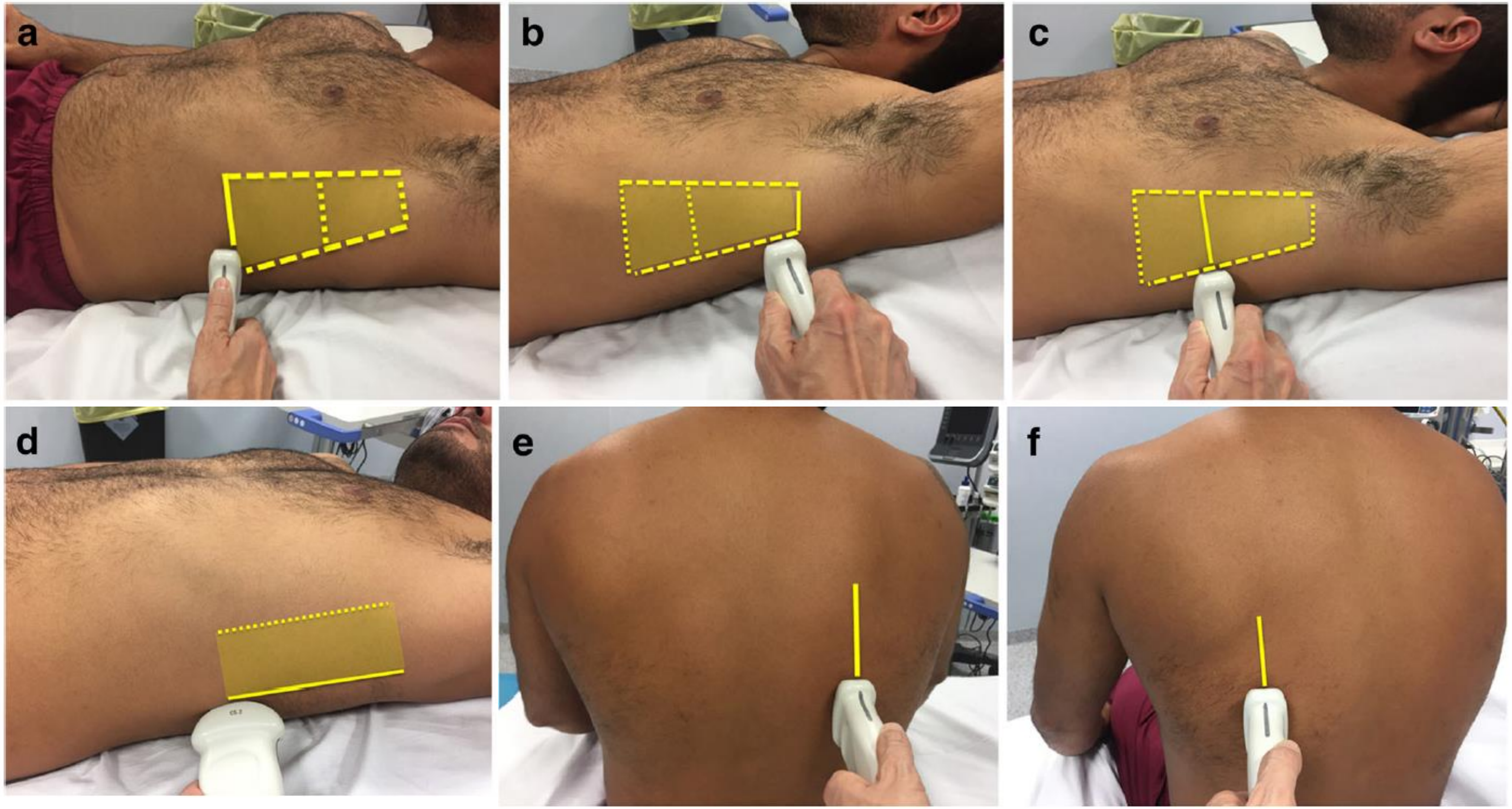
F. Remerand et al. ICM (2010) 36:656-664

Pleural effusion

- Pleural effusion
  - Superior than X-ray for detection
    - X ray : about 300cc at lateral decubitus
    - Lung ultrasound : about 20cc
  - Superior than CT for fluid characteristics
    - Transudate or exudate
    - Complicated exudate
    - Empyema



LUS evaluation for pleural effusion or empyema



Brogi et al. Critical Care (2017) 21:325

High risk of empyema in COPD

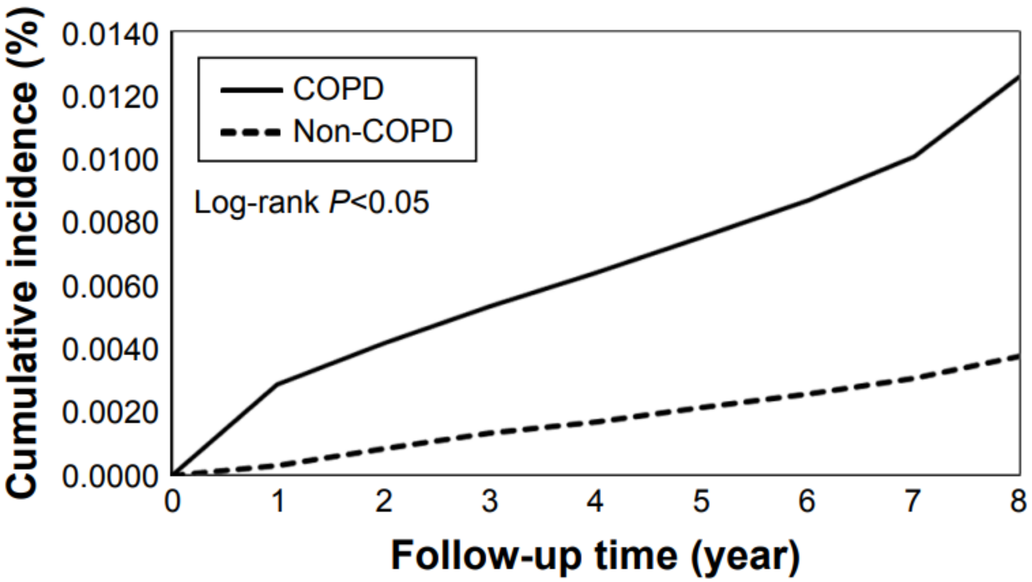


Figure 2 Cumulative incidence of empyema in patients with and without COPD.

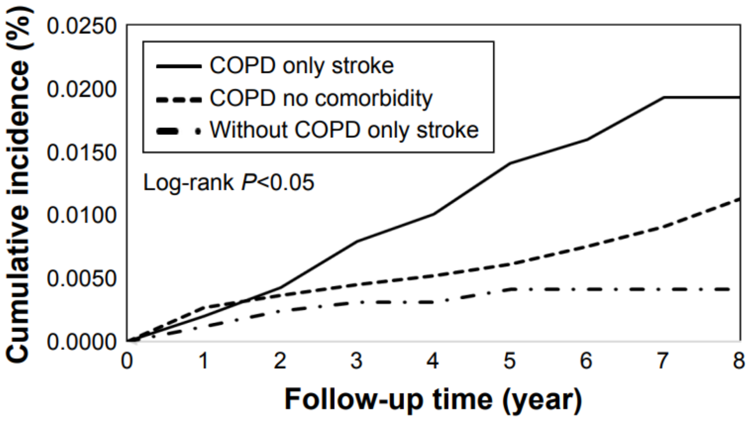


Figure 4 Cumulative incidence of empyema in patients with only stroke.

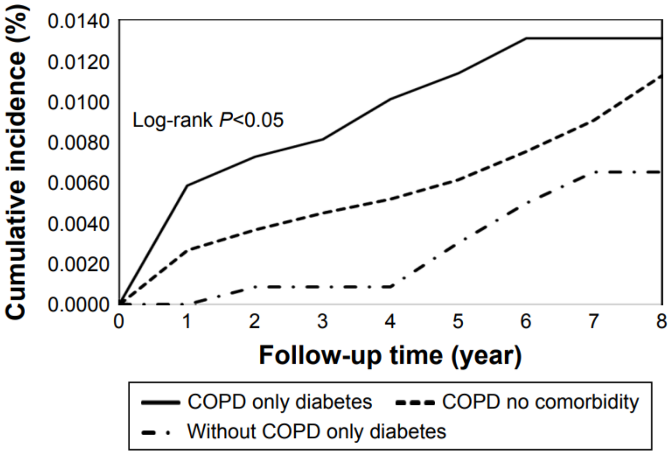


Figure 3 Cumulative incidence of empyema in patients with only diabetes.

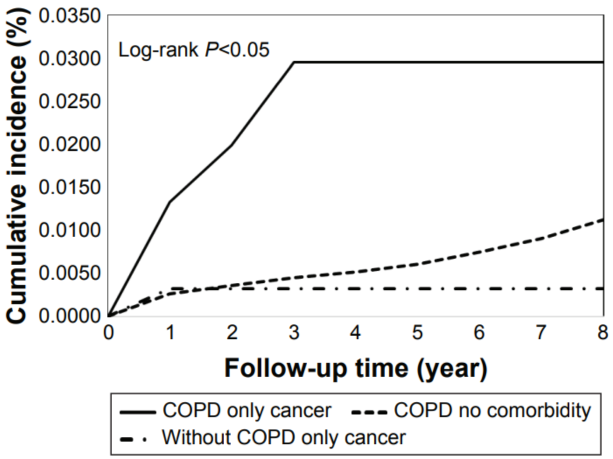
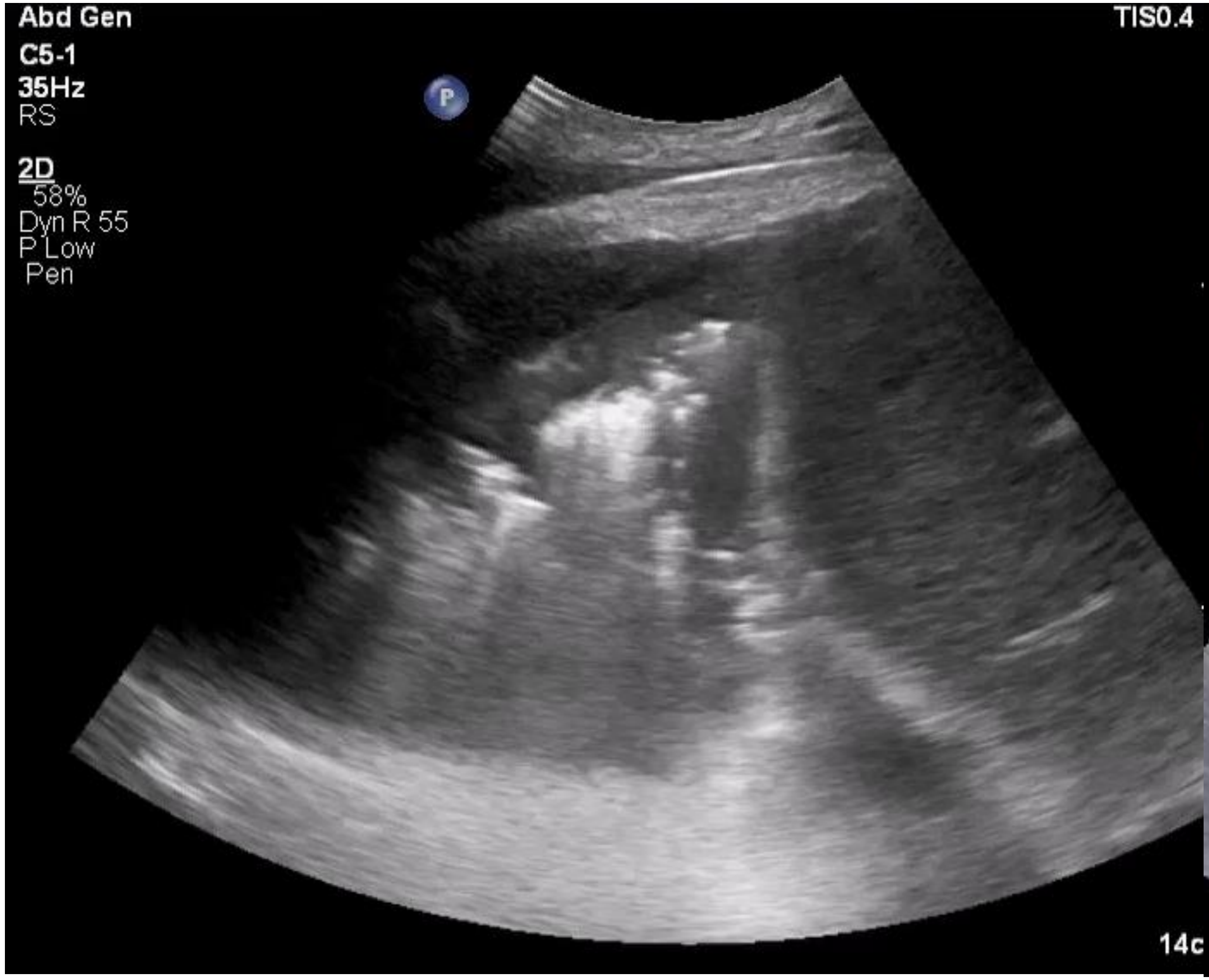
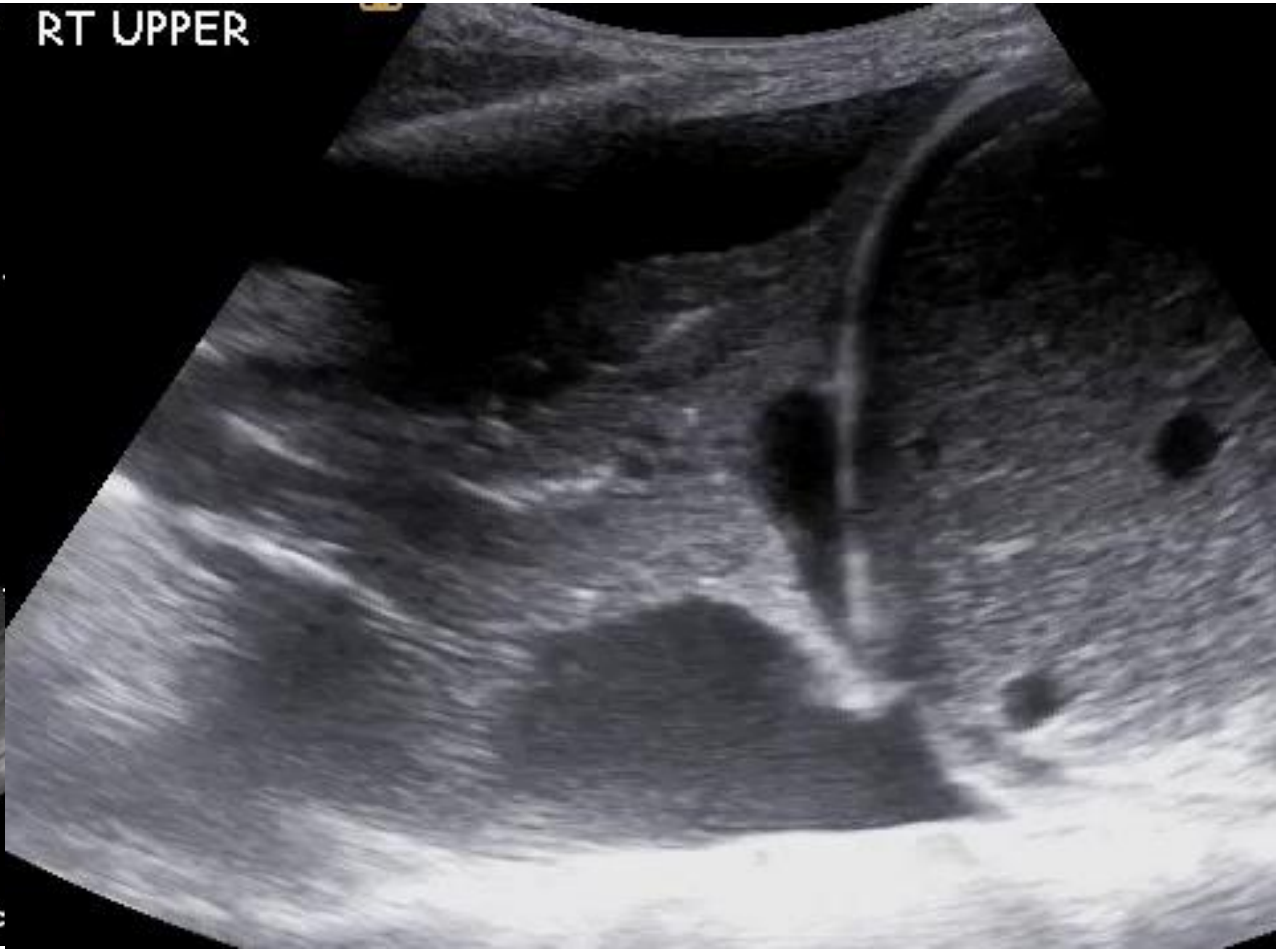


Figure 5 Cumulative incidence of empyema in patients with only cancer.

International Journal of COPD 2018:13

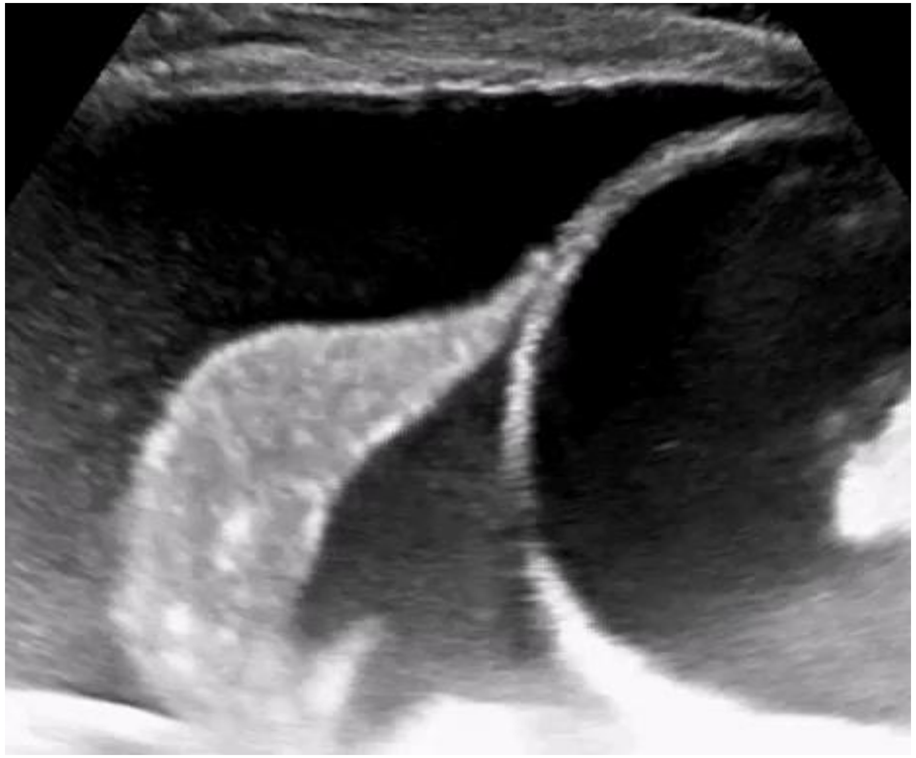
LUS: Nature of pleural effusion



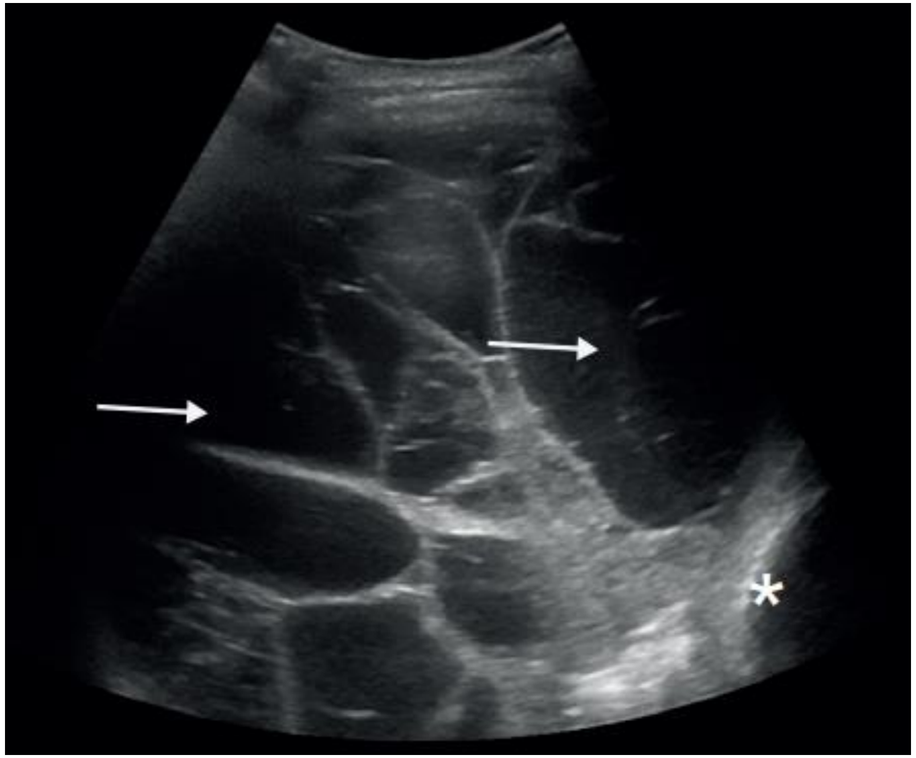


LUS: Nature of pleural effusion

Large pleural effusion with plankton sign

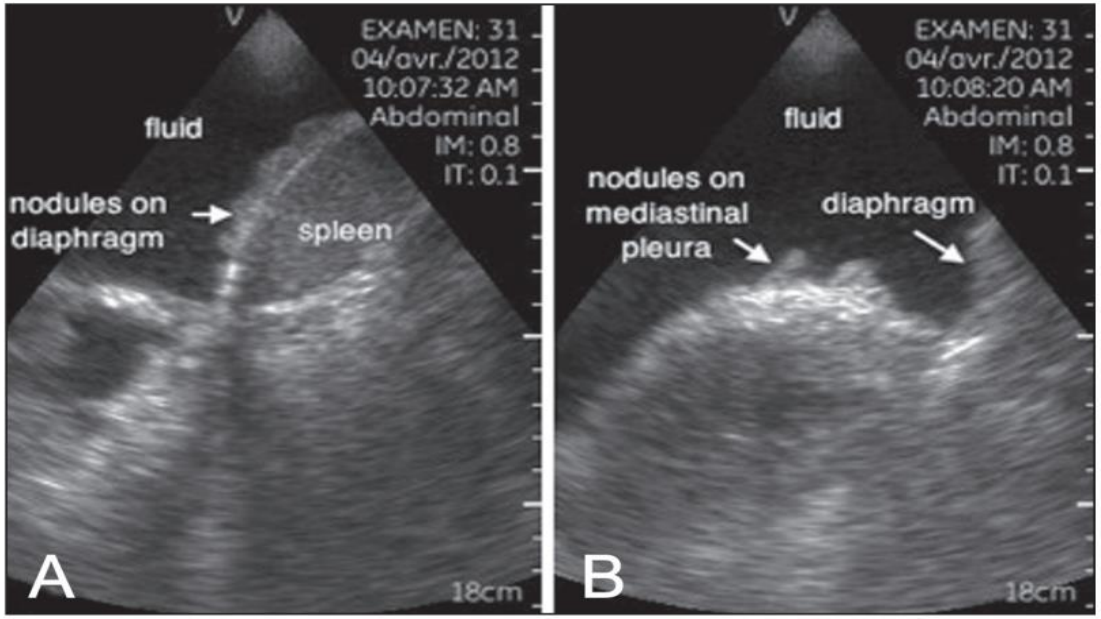


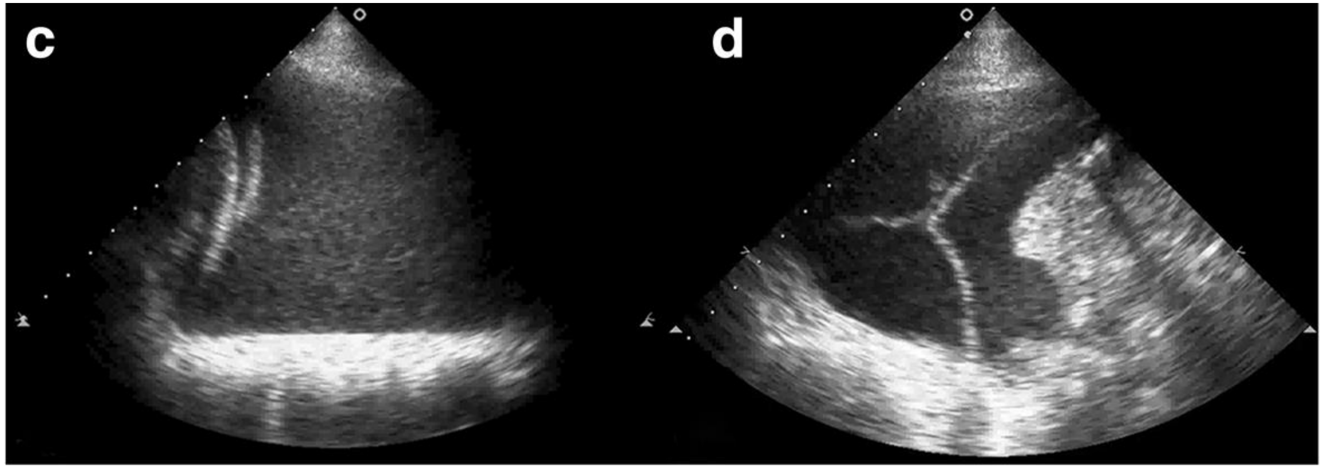
Pleural effusion with multiple thin walled septation



Data from TJ An
M.R. Vial et al. US Respiratory & Pulmonary disease, 2017;2(1):23-25

LUS: Nature of pleural effusion





c: Hemothorax, d: complex septation pleural effusion

Nodules on diaphragm or parietal pleura

Pleural thickening > 7mm

B Grondin-Beaudoin Can Respir J (2013) 20(1)

NR Qureshi et al. Throax 2009;64:139-143

Measurement of Diaphragm in COPD

Diaphragm muscle

- Primary respiratory muscle
  - **Diaphragm muscle**
  - External intercostals

- Accessory respiratory muscle
  - Inspiratory: SCM, scalenus, pectoralis, serratus anterior, latissimus dorsi etc.
  - Expiratory: rectus abdominis, external/internal oblique, transverse abdominis etc.

Diaphragm muscle

Anatomy

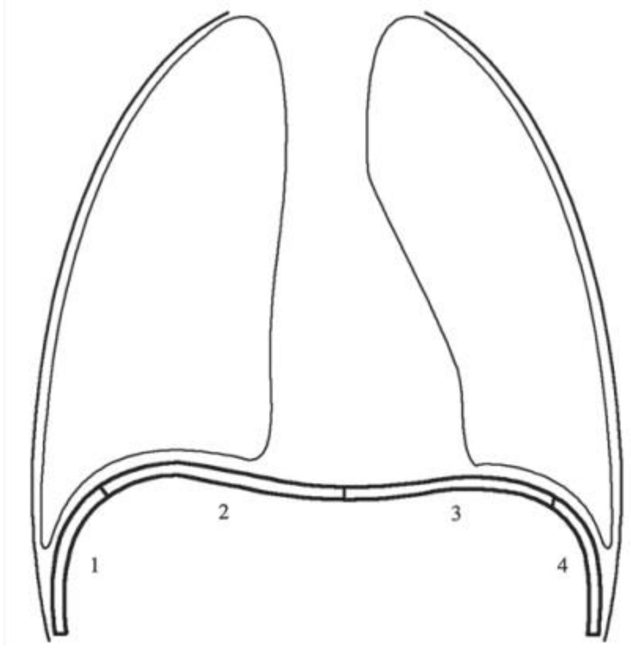
- Tendinous portion (central tendon)
- Muscular portion (periphery): zone of apposition

Functional markers of diaphragm dysfunction

- Zone of apposition

  : Diaphragm thickness, Diaphragm thickening fraction
- Dome

  : Diaphragm excursion



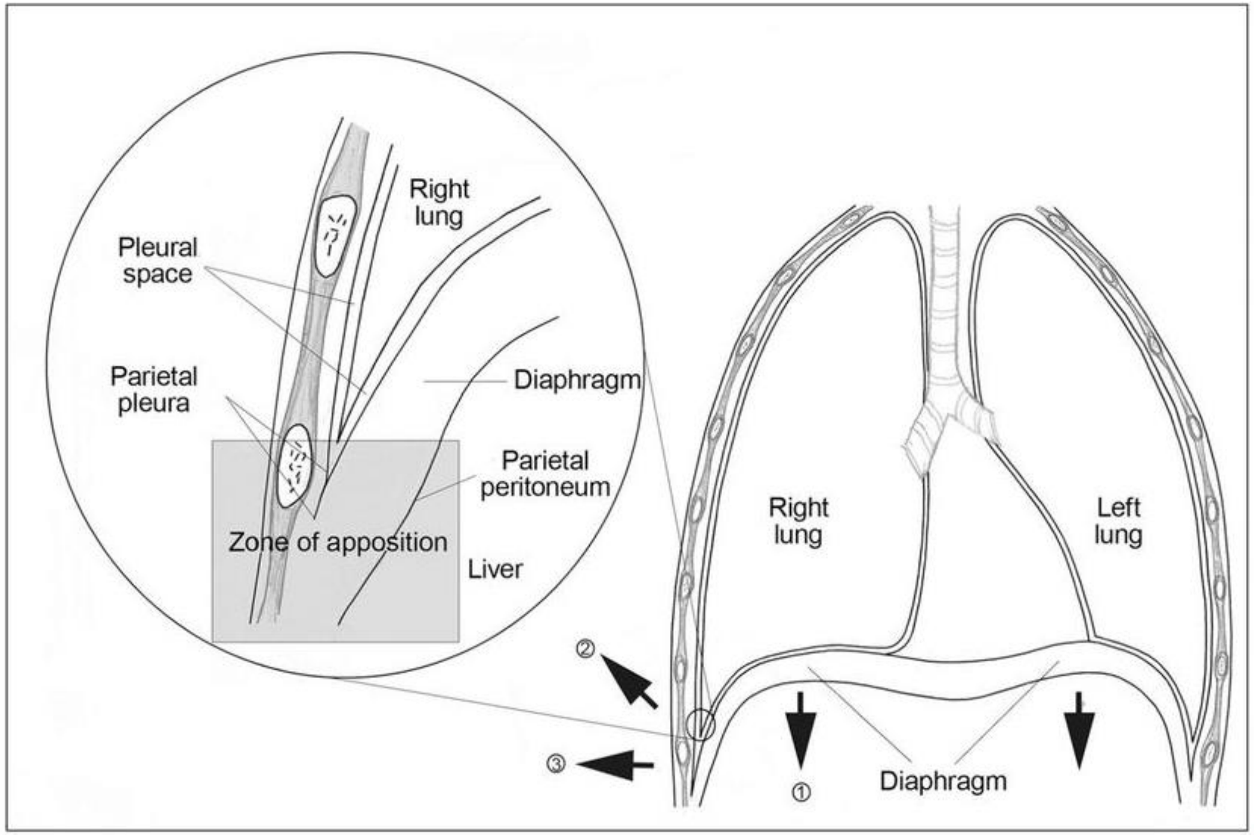
The four functional areas of the diaphragm

1,4 - Rt. & Lt. appositional area

2, 3 - Rt. & Lt. hemi-domes

Courtesy from YJ You, The Catholic University of Korea

Diaphragm muscle: Zone of apposition



Michele Umbrello, and Paolo Formenti Respir Care
2016;61:542-555

- Changes with respiration
- T8~L1
- Controlled by direct diaphragm tension

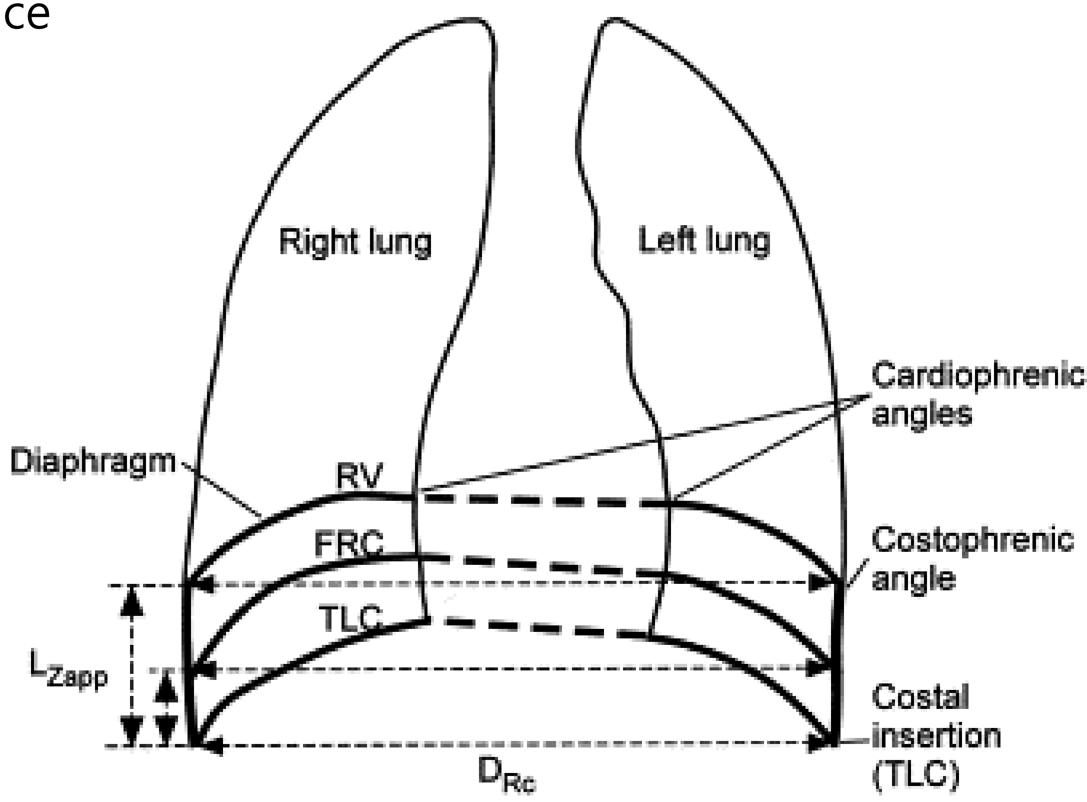
  \+ abdomen m./oblique m.
- At end of expiration with resting position

  → related with accessory m. use, chest wall mobility, and lung hyperinflation

Diaphragm muscle: Zone of apposition

Intercostal view

- Probe: high frequency linear probe (7-18MHz)
- Location: anterior-mid axillary line, 8th – 10th intercostal space



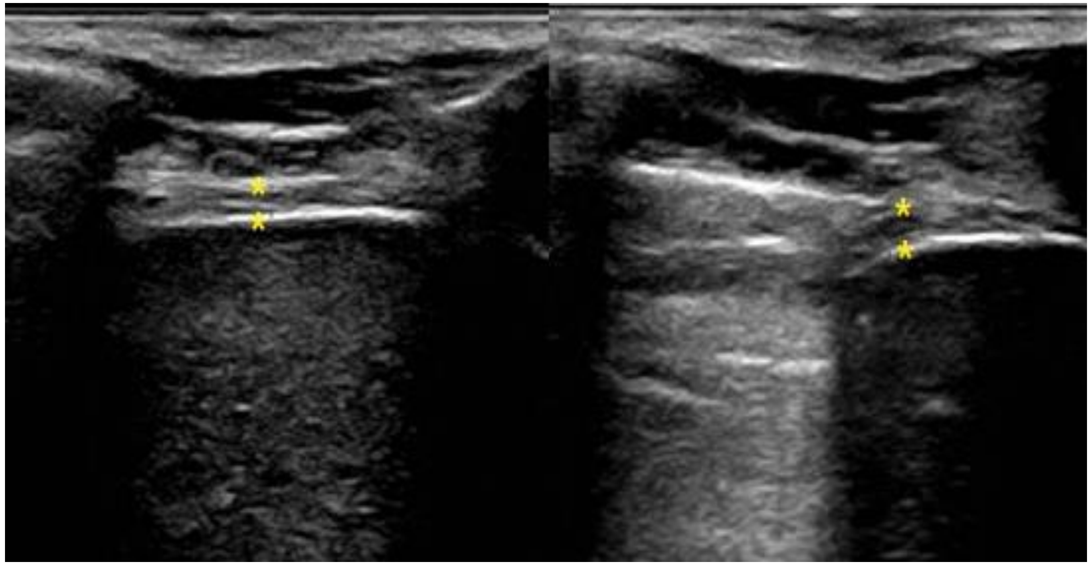
$$L_{Di} = 2 \times (0.98 \times L_{Zapp} + 0.46 \times D_{Rc} + 35)$$

Crimi et al. IJCOPD 2018:13 3131-3139

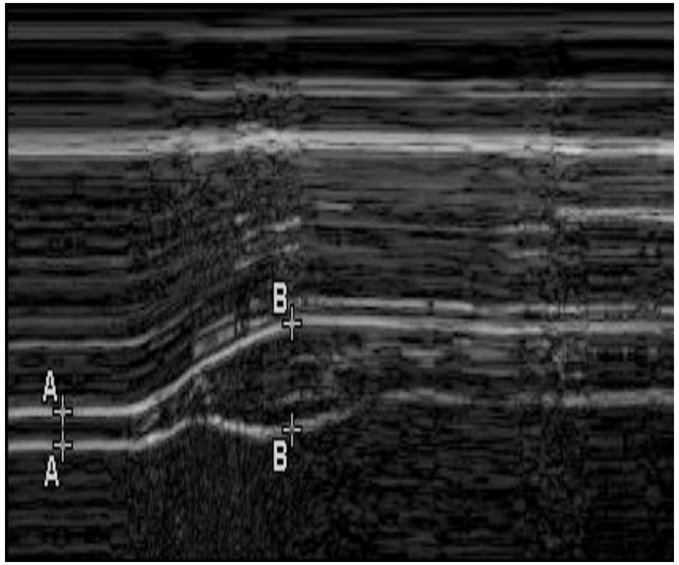
Diaphragm muscle: Thickness, Thickening Fraction

Diaphragm thickness

B-mode measurement



M-mode measurement



A) end-expiration
B) peak inspiratory muscle contraction

Diaphragm thickening fraction (= Change in thickness)

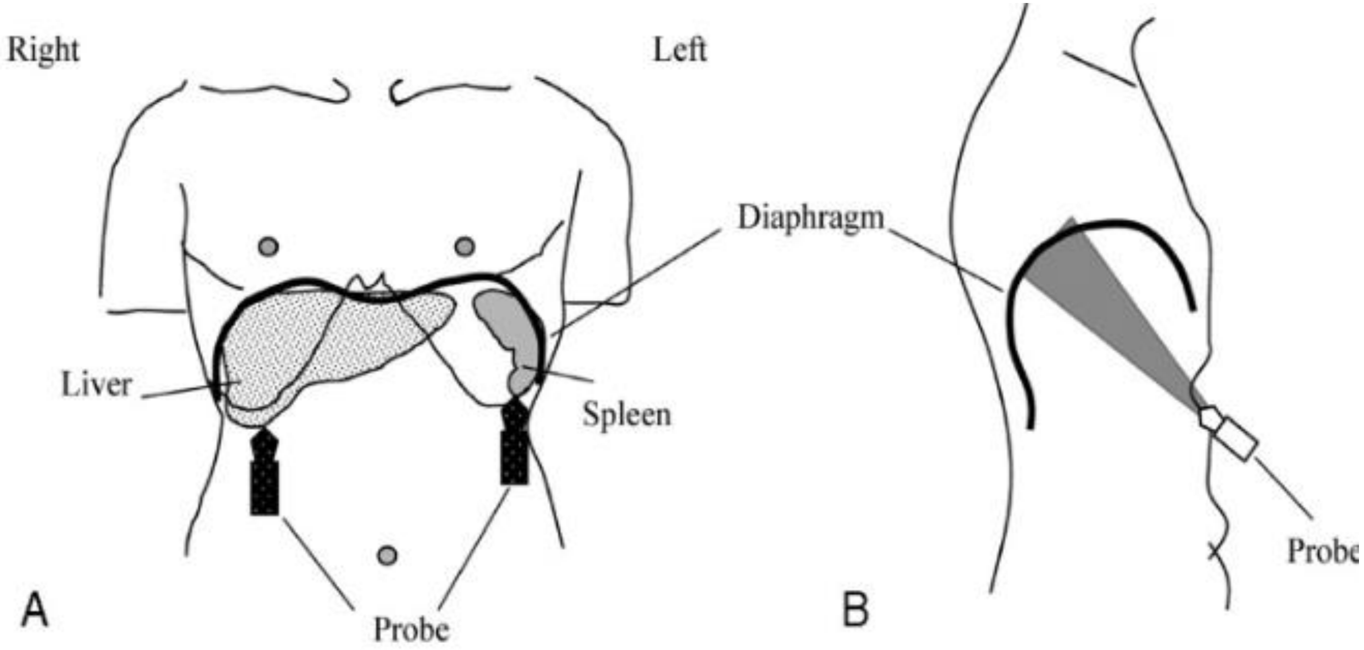
$$\frac{(\text{Thickness at end}-\textit{inspiration})-(\text{Thickness at end}-\textit{expiration})}{(\text{Thickness at end}-\textit{expiration})} \times 100(\%)$$

Intensive Care Med 2015;41:642-649

Diaphragm muscle: anterior subcostal view

Anterior subcostal view

- Probe: low frequency convex probe (2-6MHz)
- Location: below the costal margin, mid-clavicular line, posterior third of the diaphragm

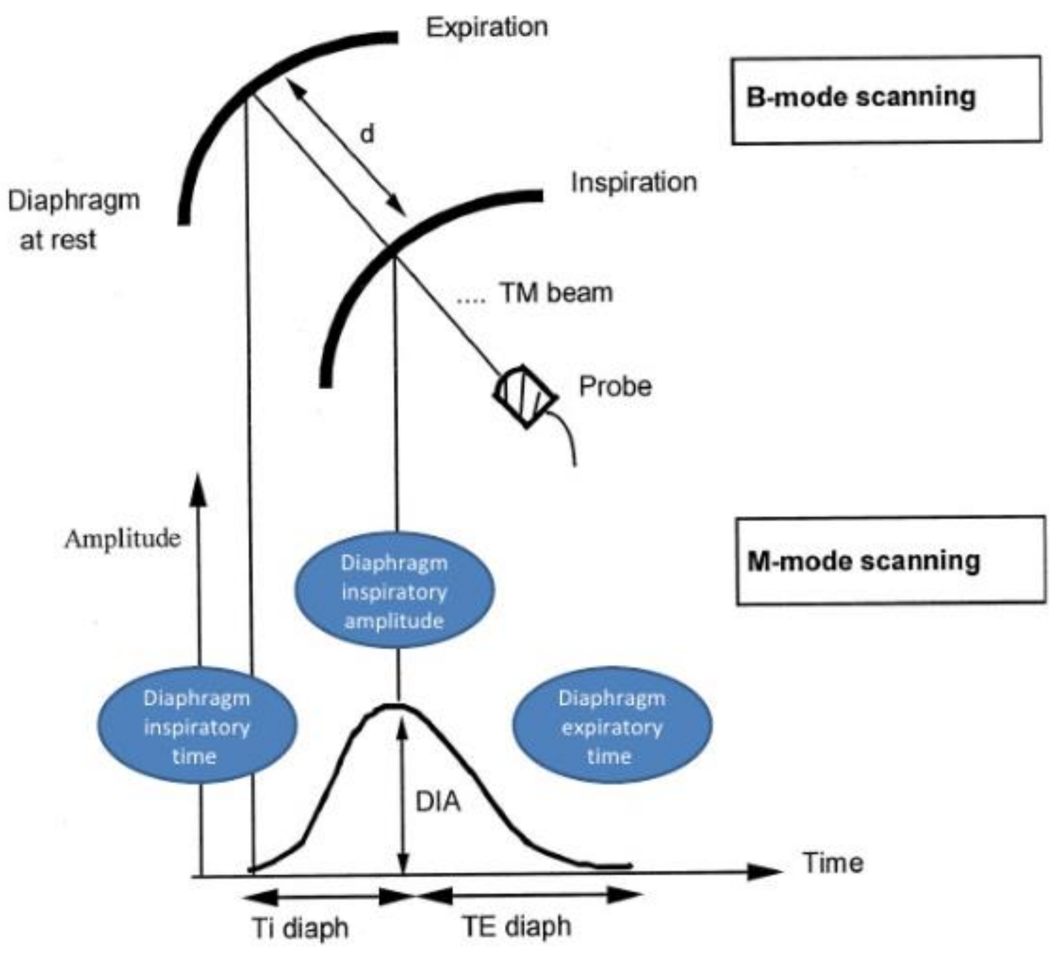


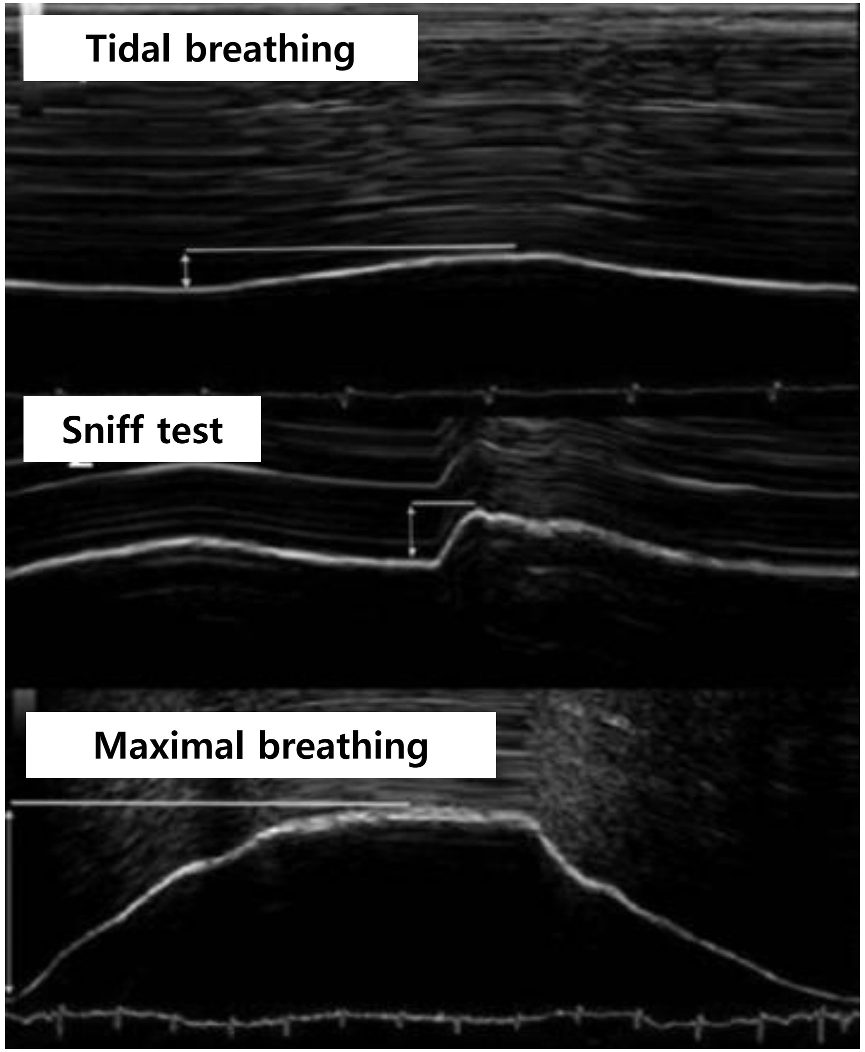
Usually measured in Rt hemi-diaphragm

- No definite difference between Rt and Lt hemi-diaphragm
- Rt: Good liver window
- Lt: Small spleen window, combined with bowel gas

Boussuge et al. Chest 2009;135:391-400

Diaphragm muscle: Diaphragm excursion

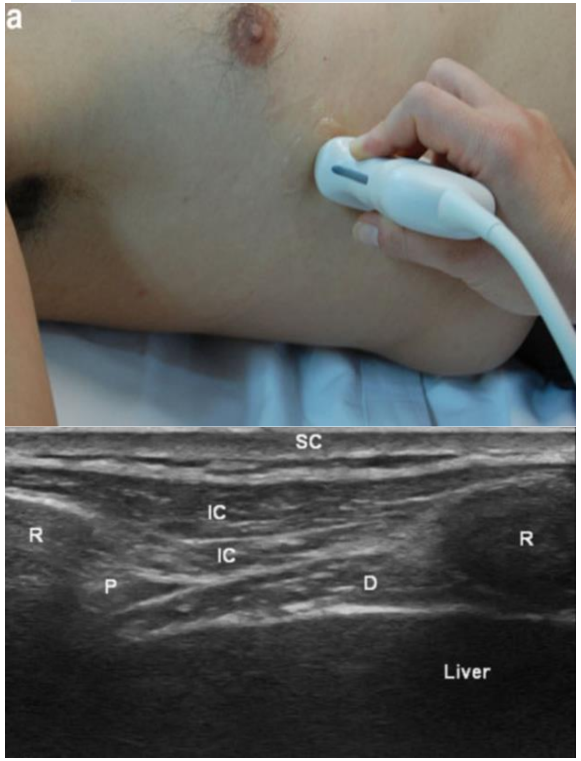




Boussuge et al. Chest 2009;135:391-400

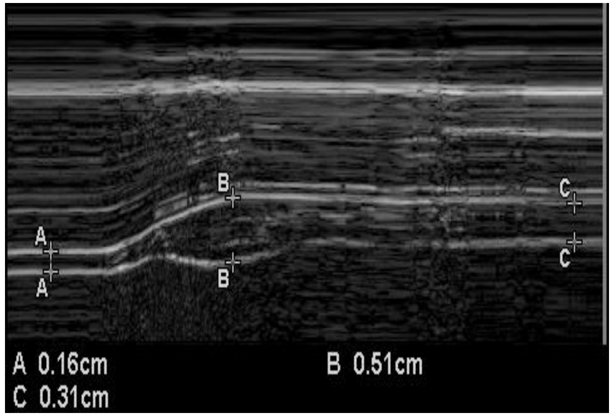
DUS is good for evaluation of diaphragm muscle

Diaphragm mass



Cut-off values: < 2mm

Diaphragm driving power

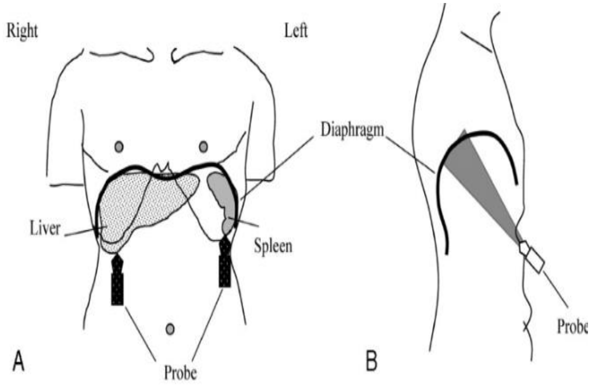


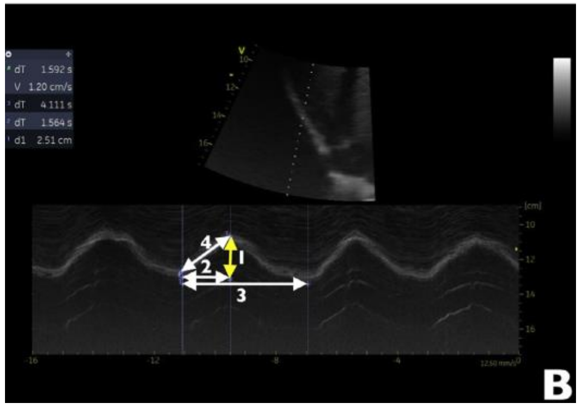
A) end-expiration
B) peak inspiratory muscle contraction

(B-A)/A = Diaphragm thickening fraction (TF)

Cut-off values: < 20%

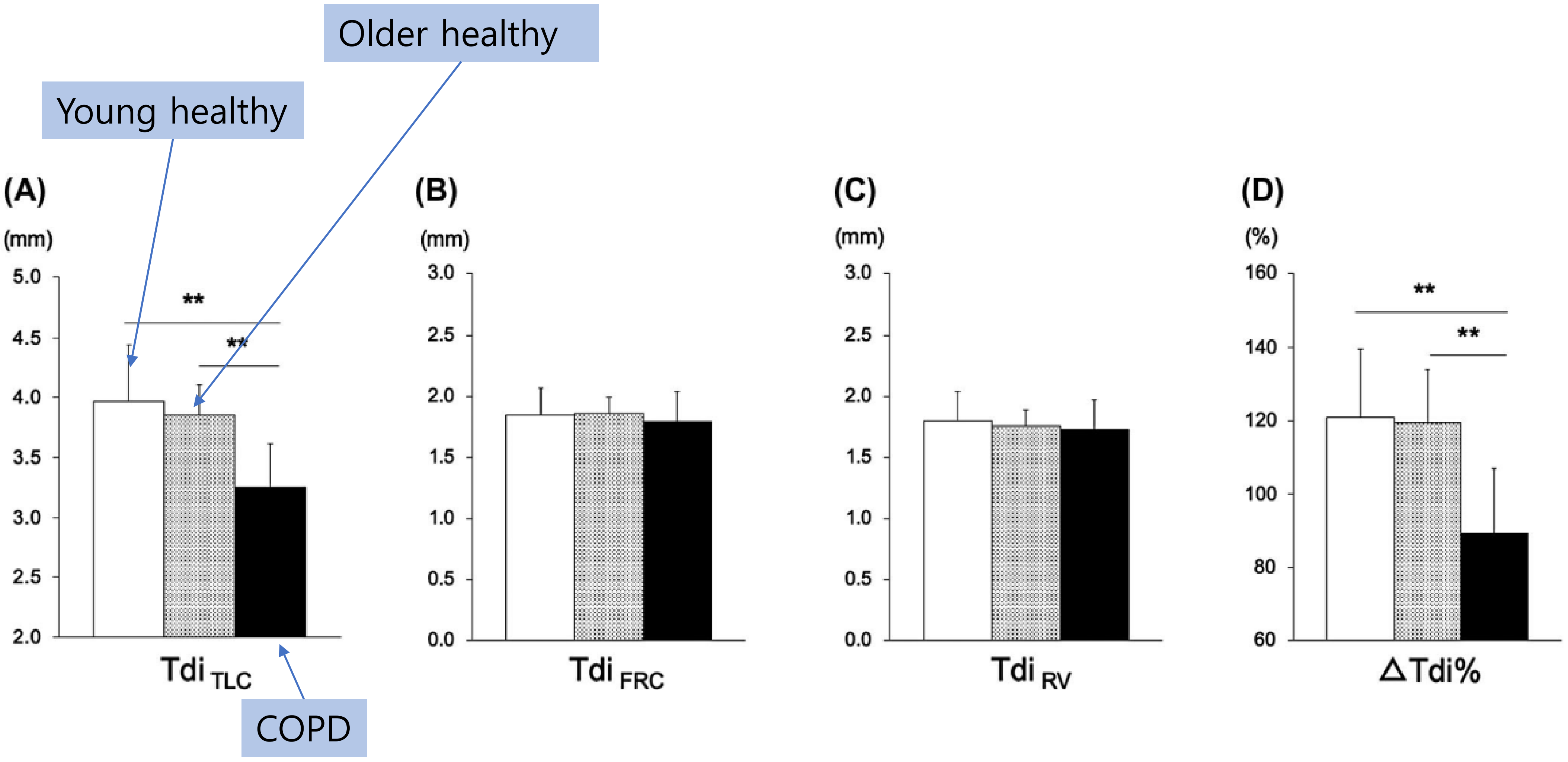
Diaphragm mobility





Cut-off values: <50mm

Diaphragm by DUS is differs in COPD



Clin Respir J. 2020;14:521–526.

Diaphragm adaptations in COPD

Respiratory Research

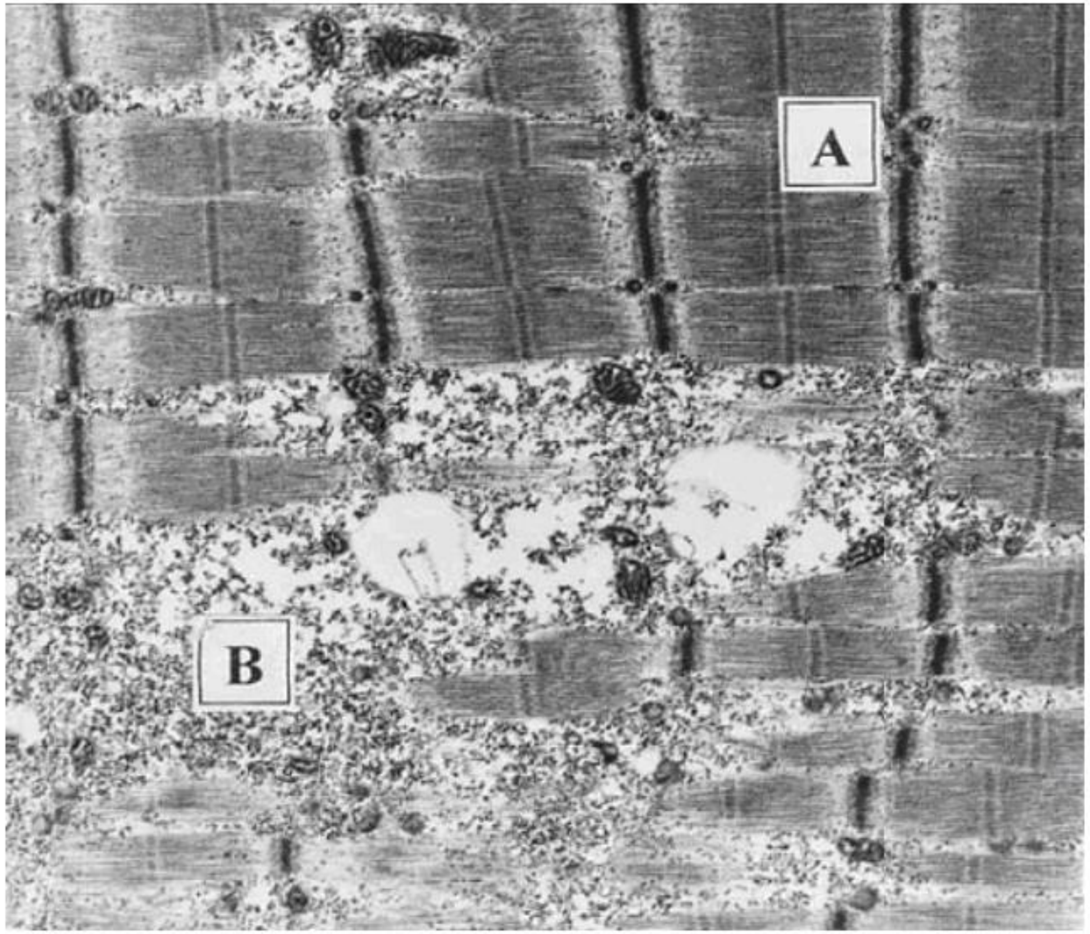
BioMed Cent

Review

Open Acce

Diaphragm adaptations in patients with COPD

Coen AC Ottenheijm*[4], Leo MA Heunks[1,2,3] and Richard PN Dekhuijzen[1,3]

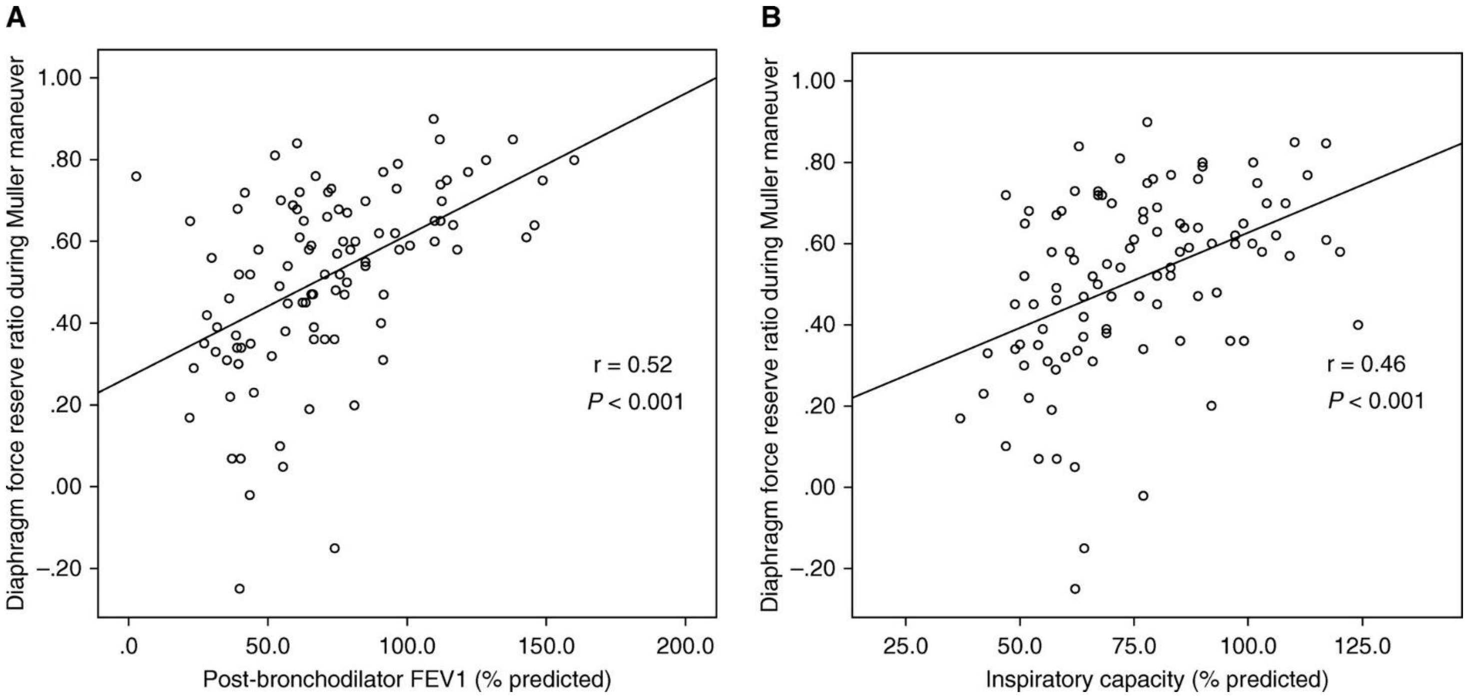


Respiratory Research 2008, 9:12

Diaphragm function and lung function: force reserve

Ultrasound Evaluation of Diaphragm Force Reserve in Patients with Chronic Obstructive Pulmonary Disease

Nuttapol Rittayamai[1], Benjamas Chuaychoo[1], Jamsak Tscheikuna[1], Martin Dres[2], Ewan C. Goligher[3,4,5,6,7], and Laurent Brochard[7,8]



Diaphragm muscle power or reserve → Correlated with lung function

N.Rittayamia et al. AnnalsATS 2020;17:10

Diaphragm function and lung function: force reserve

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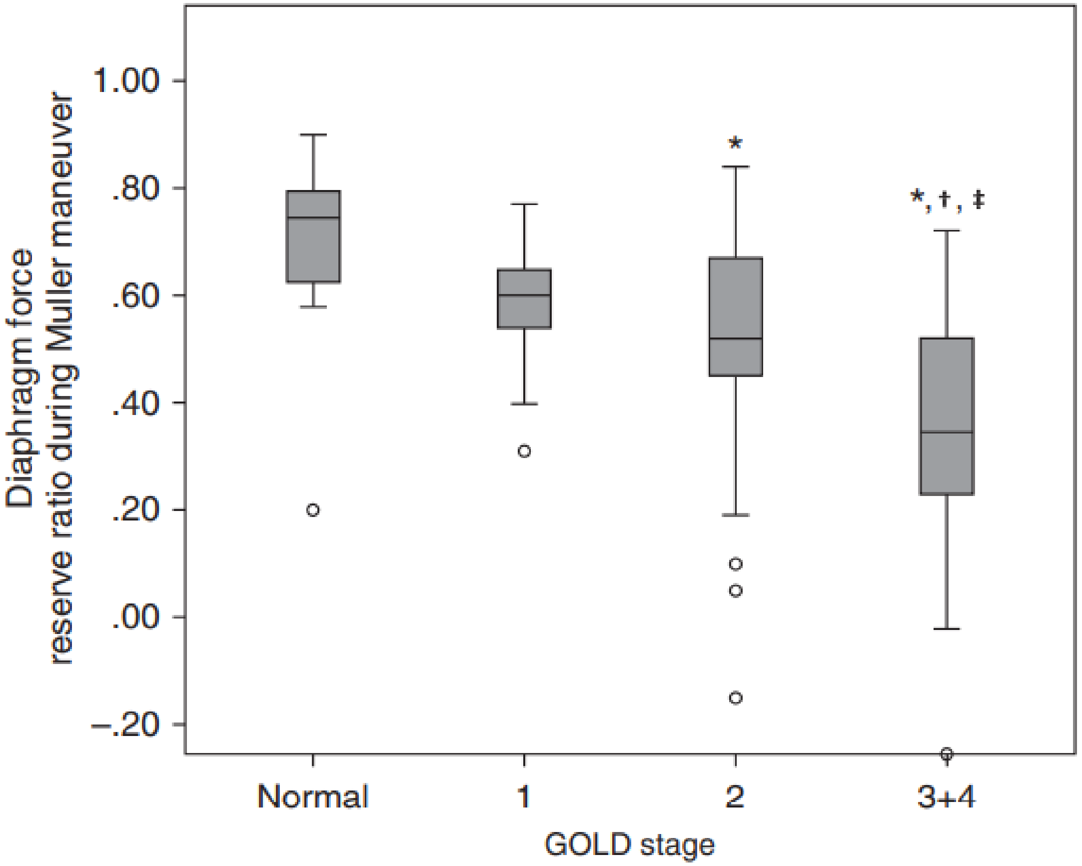
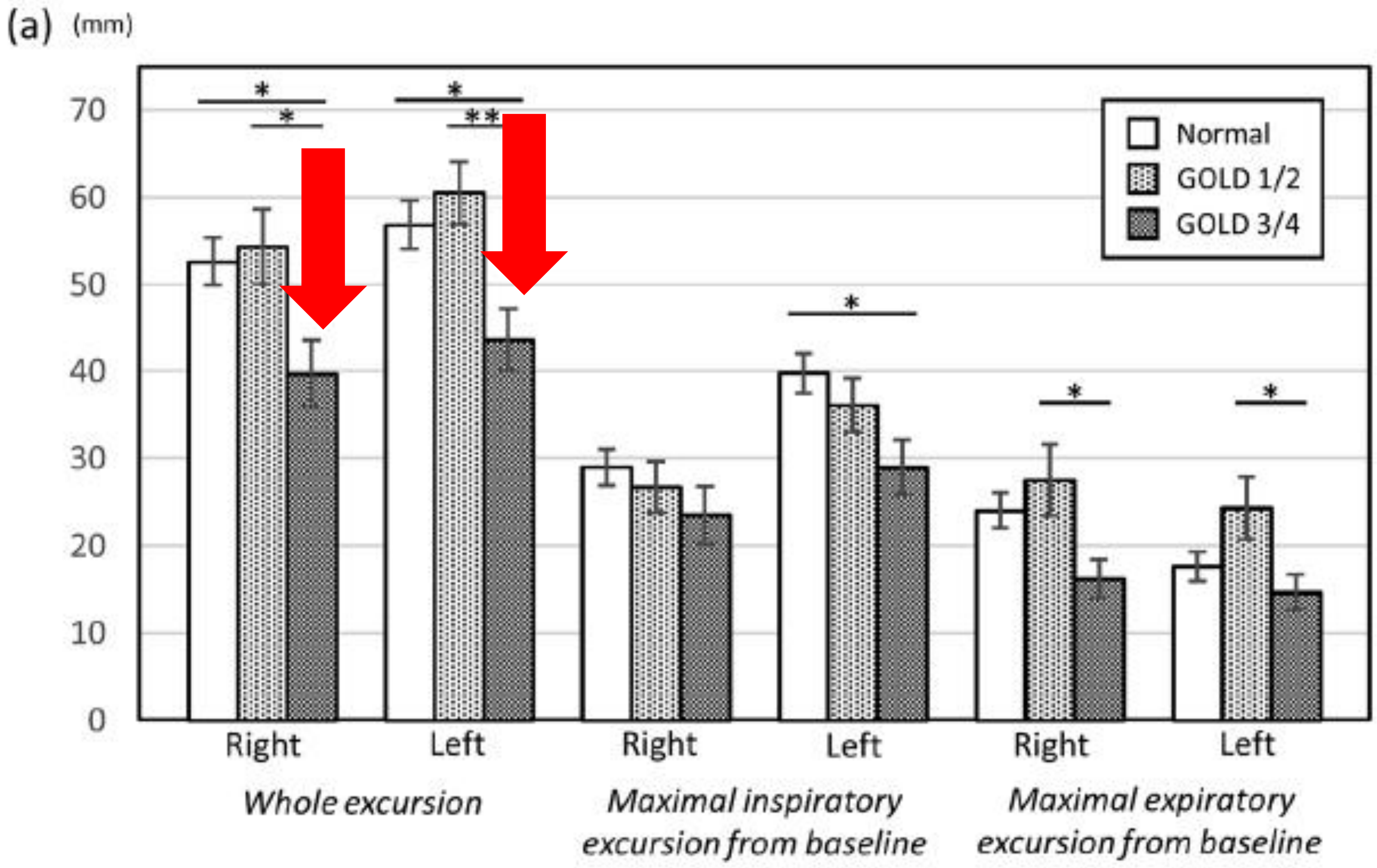


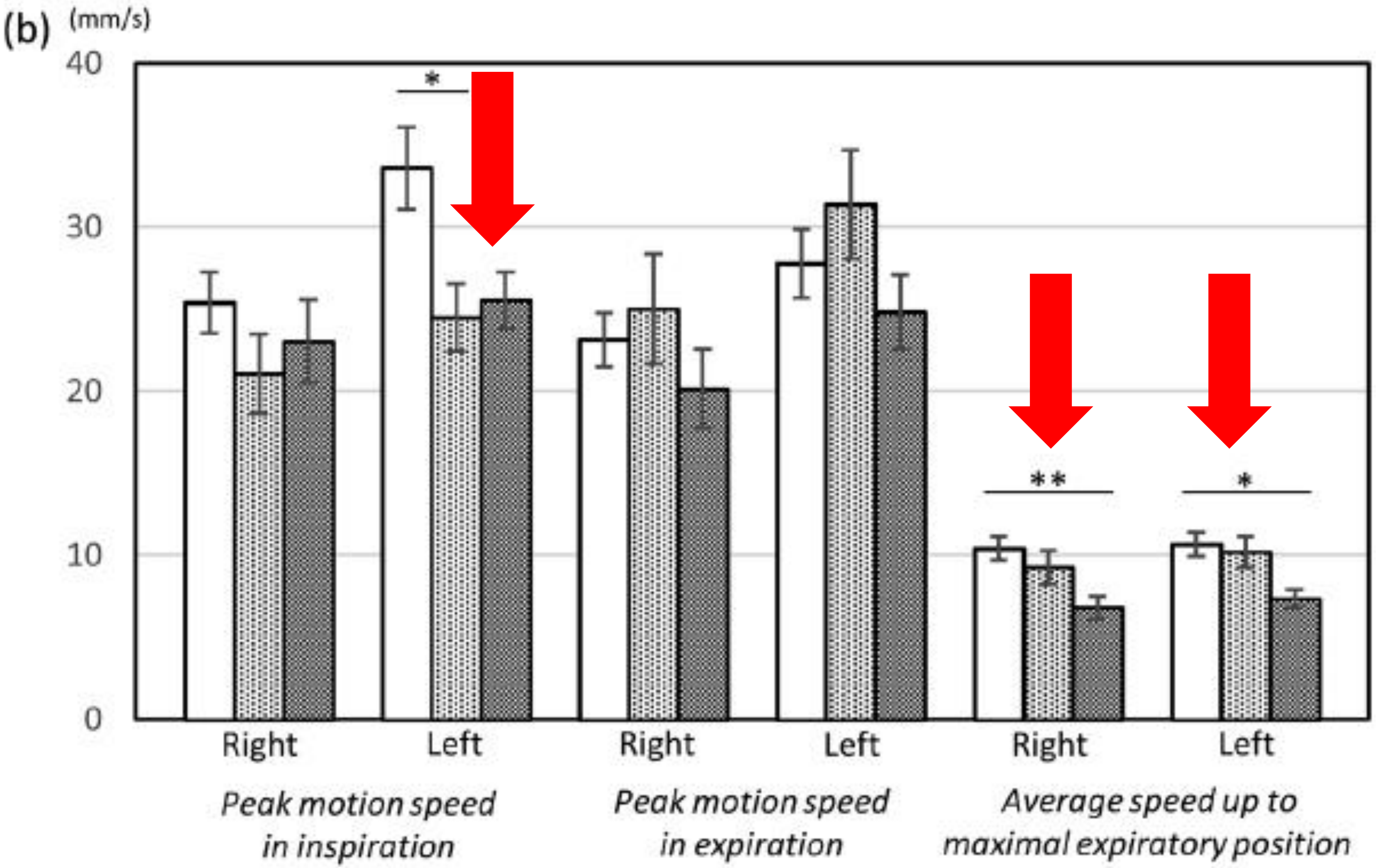
N.Rittayamia et al. AnnalsATS 2020;17:10

Diaphragm mobility differs by COPD stages



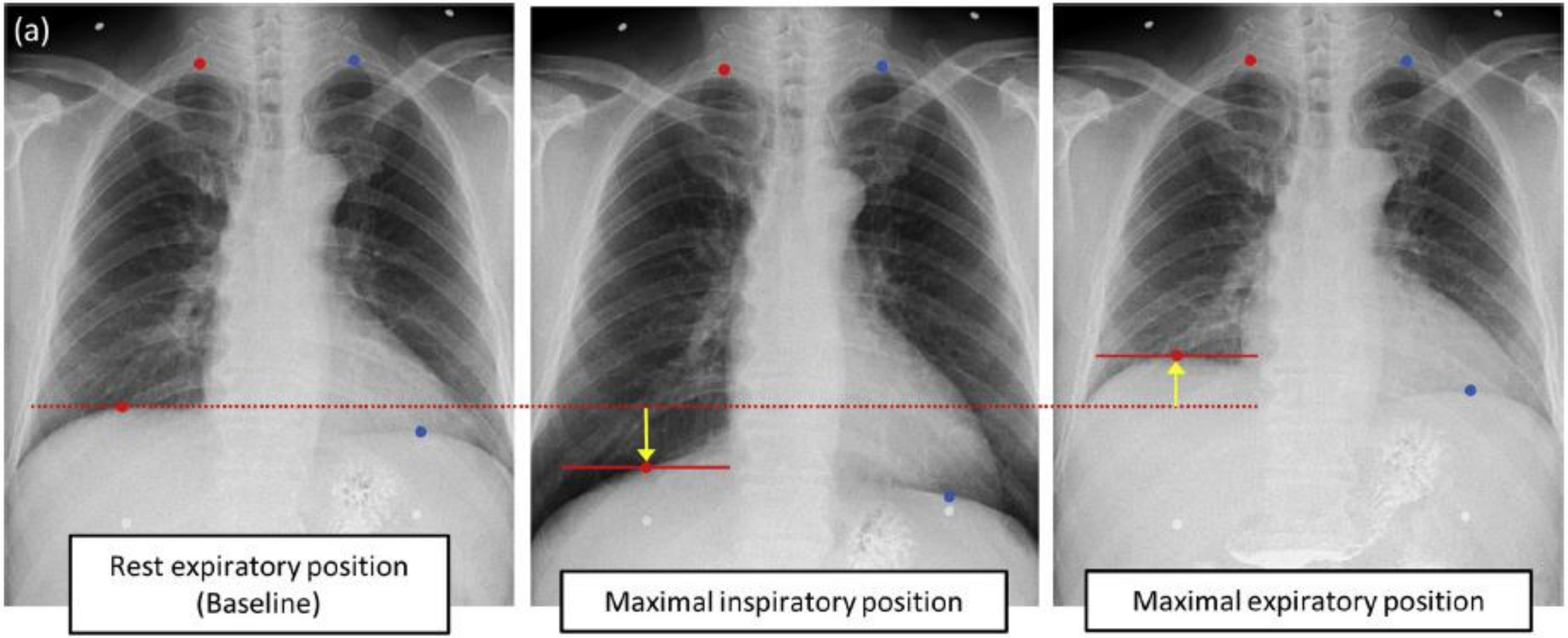
European Journal of Radiology 112 (2019) 28–36 30

Diaphragm velocity differs by COPD



European Journal of Radiology 112 (2019) 28–36 30

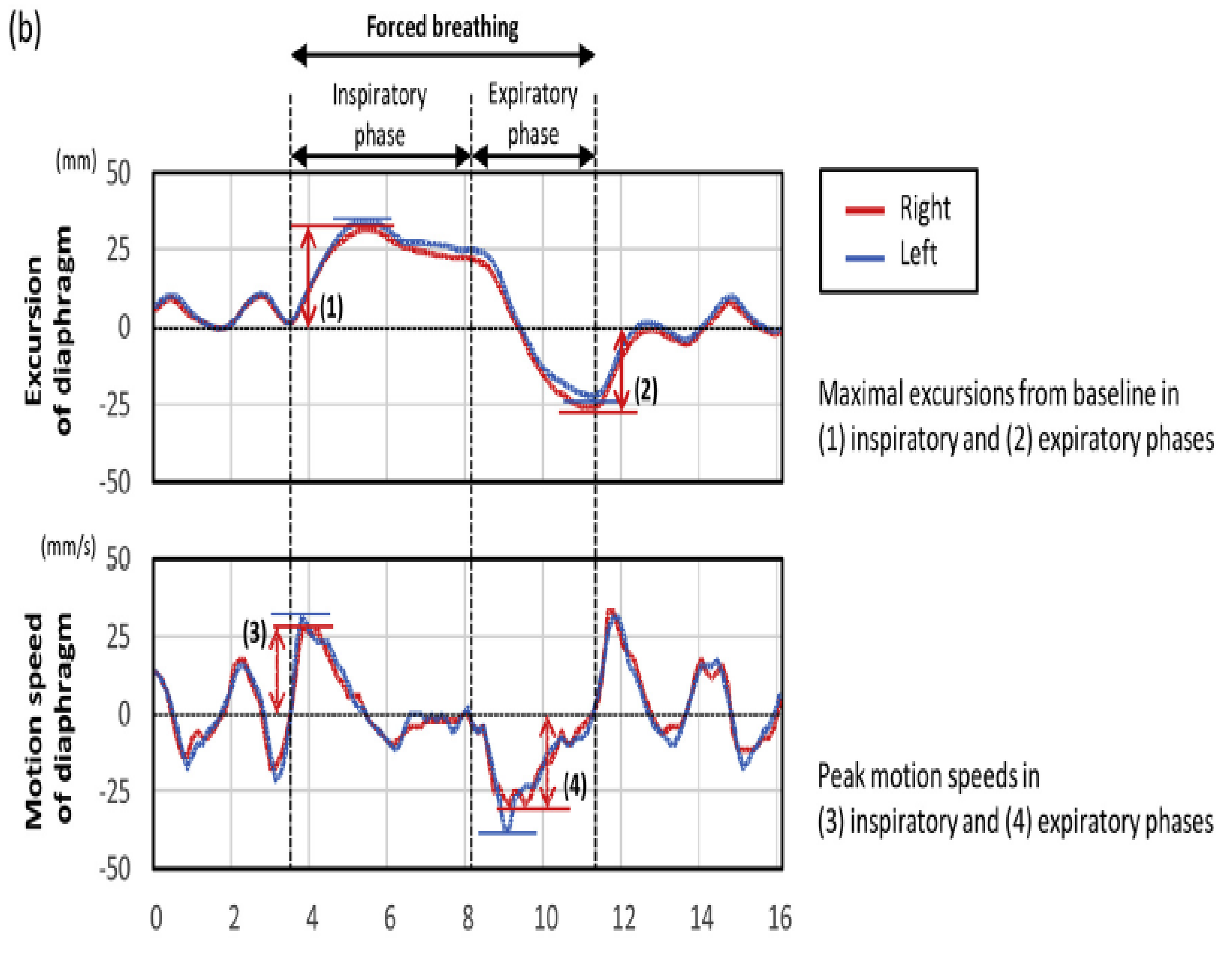
COPD: Breathing pattern/Physiologic difference



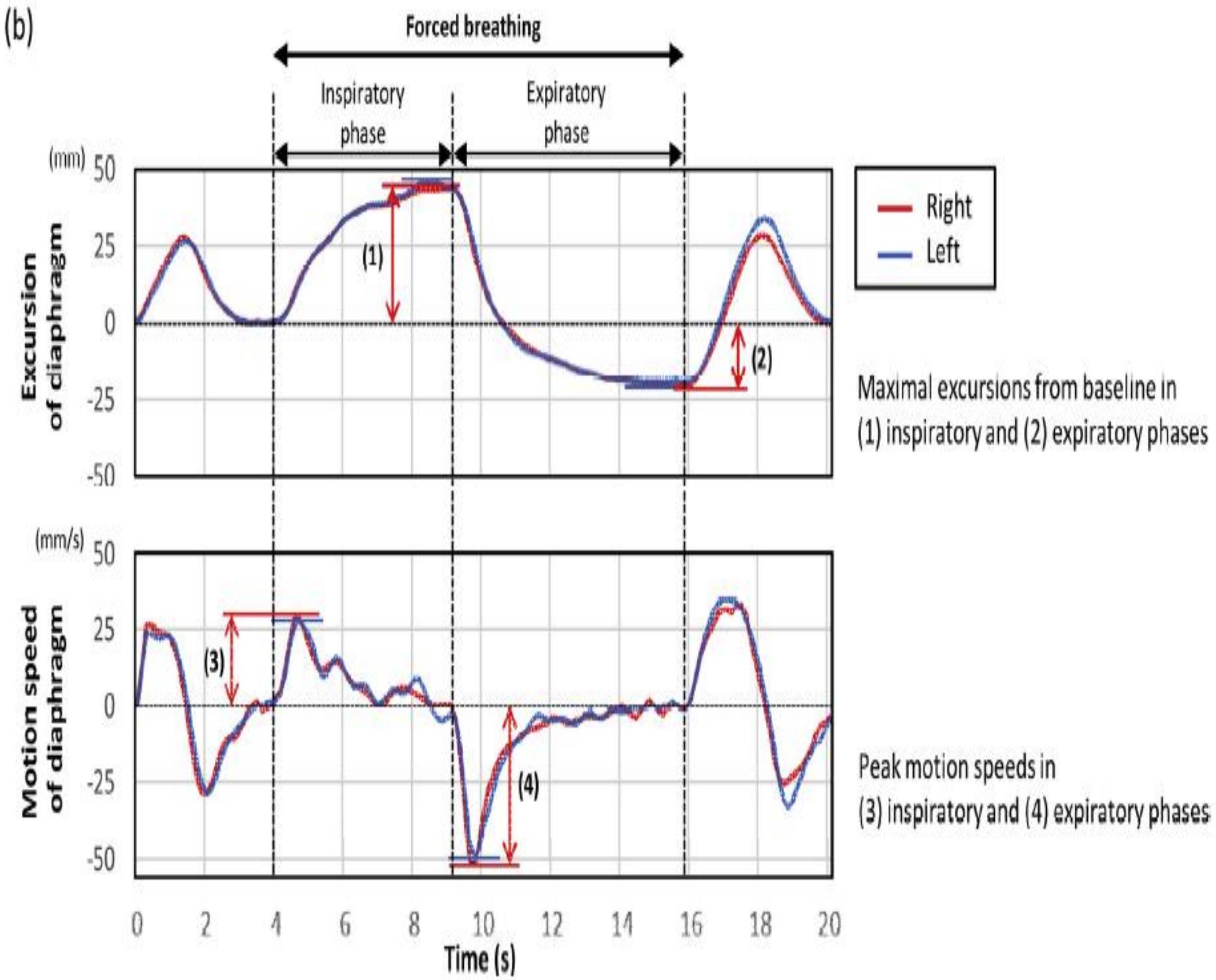
European Journal of Radiology 112 (2019) 28–36 30

COPD: Breathing pattern/Physiologic difference

50yrs, normal PFT



70yrs, GOLD 3 COPD



European Journal of Radiology 112 (2019) 28–36 30

Stable vs. AECOPD

International Journal of Chronic Obstructive Pulmonary Disease
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Open Access Full Text Article
ORIGINAL RESEARCH

Diaphragm Ultrasound is an Imaging Biomarker that Distinguishes Exacerbation Status from Stable Chronic Obstructive Pulmonary Disease

Table 4 Logistic Regression Analysis for Estimating Exacerbation of Chronic Obstructive Pulmonary Diseases

Model 1	**Univariate**		**Multivariate**	
	p-value	OR (95% CI)	*p*-value	OR (95% CI)
Age	0.722	0.99 (0.94–1.05)	0.682	0.98 (0.91–1.06)
Male sex	0.317	1.96 (0.53–7.28)	0.544	1.74 (0.29–10.34)
mCCI	0.049	1.62 (1.00–2.62)	0.157	1.73 (0.81–3.70)
BMI	0.007	0.80 (0.68–0.94)	0.002	0.70 (0.56–0.88)
Low TF_{max}	0.006	5.57 (1.64–18.94)	0.014	8.40 (1.55–45.56)
Model 2	**Univariate**		**Multivariate**	
Age	0.722	0.99 (0.94–1.05)	0.233	0.95 (0.88–1.03)
Male sex	0.317	1.957 (0.53–7.28)	0.393	2.16 (0.37–12.67)
mCCI	0.049	1.62 (1.00–2.62)	0.032	2.68 (1.09–6.60)
BMI	0.007	0.80 (0.68–0.94)	0.022	0.79 (0.64–0.97)
Low DE_{max}	0.011	16.25 (1.92–137.78)	0.038	11.51 (1.15–115.56)

Abbreviations: mCCI, modified Charlson Comorbidity Index; BMI, body mass index; TF_{max}, diaphragm thickening fraction during maximal deep breathing; DE_{max}, diaphragm excursion during maximal deep breathing.

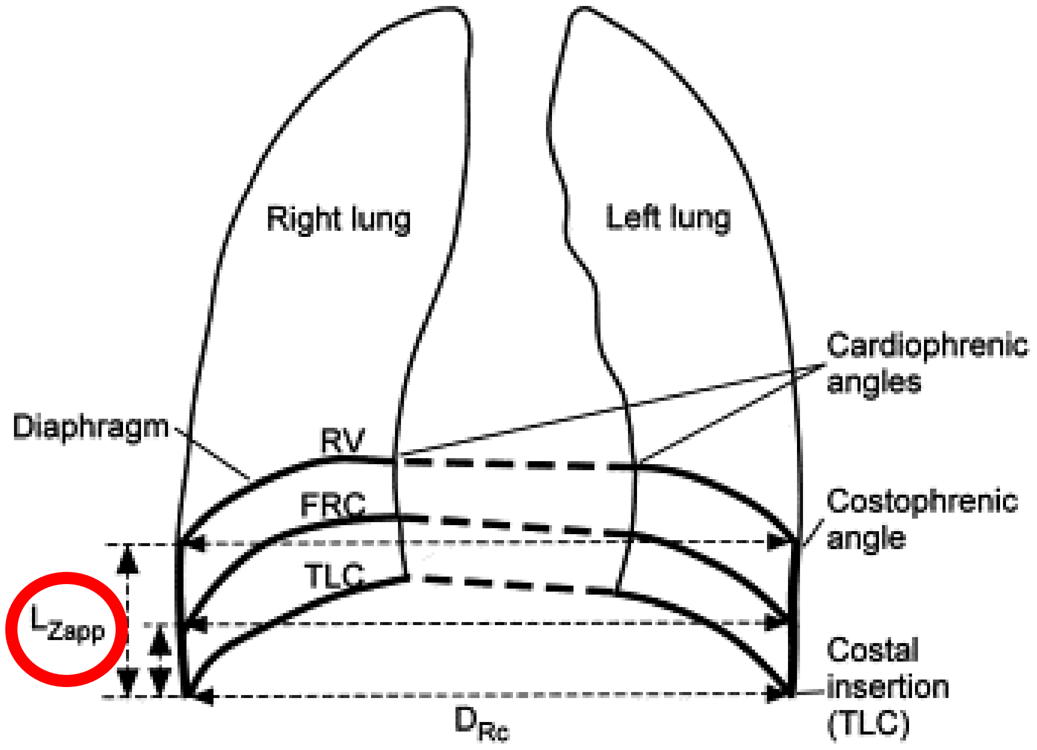
TJ An et al. Int J Chron Obstruct Pulmon Dis . 2022 Jan 4;17:3-12

Before vs after Pul rehab

International Journal of COPD
Dovepress
open access to scientific and medical research
Open Access Full Text Article
ORIGINAL RESEARCH

Utility of ultrasound assessment of diaphragmatic function before and after pulmonary rehabilitation in COPD patients

- 호흡재활 전후로 비교
- L_{Zapp} = Length of Zone of apposition
- S_{Zapp} = Thickness of Zone of apposition



$$L_{Di} = 2 \times (0.98 \times L_{Zapp} + 0.46 \times D_{Rc} + 35)$$

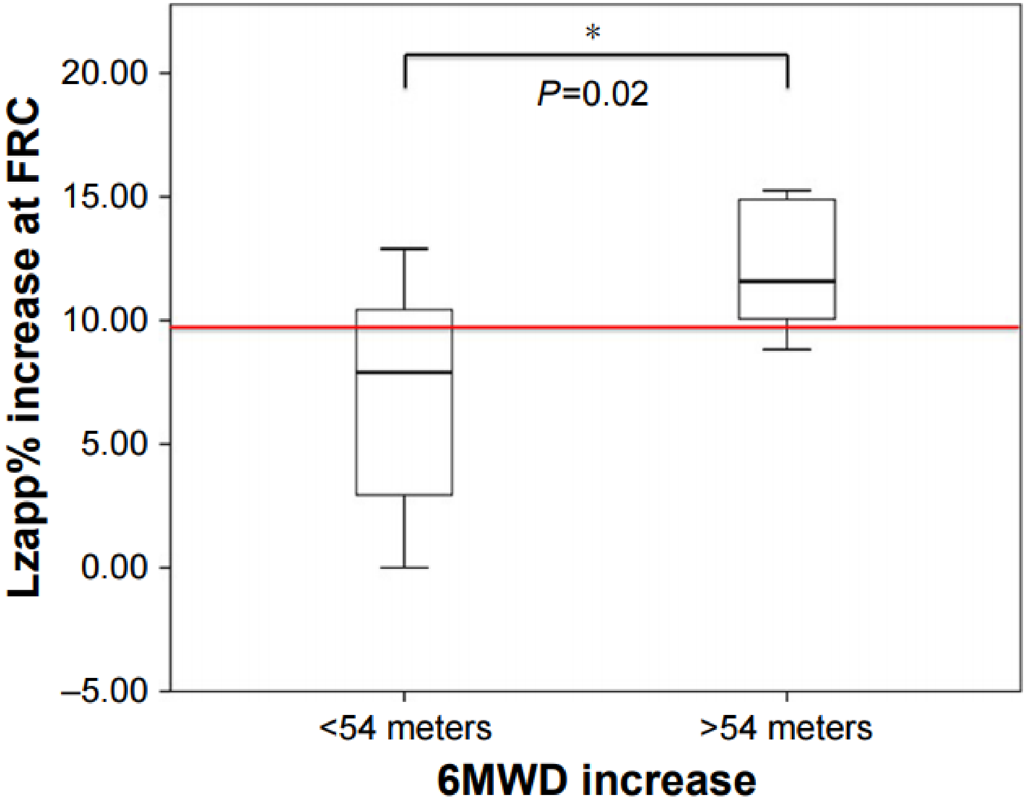
D. McKenzie et al. Respiration Physiology 123 (2000):225-234
Crimi et al. IJCOPD 2018:13 3131-3139

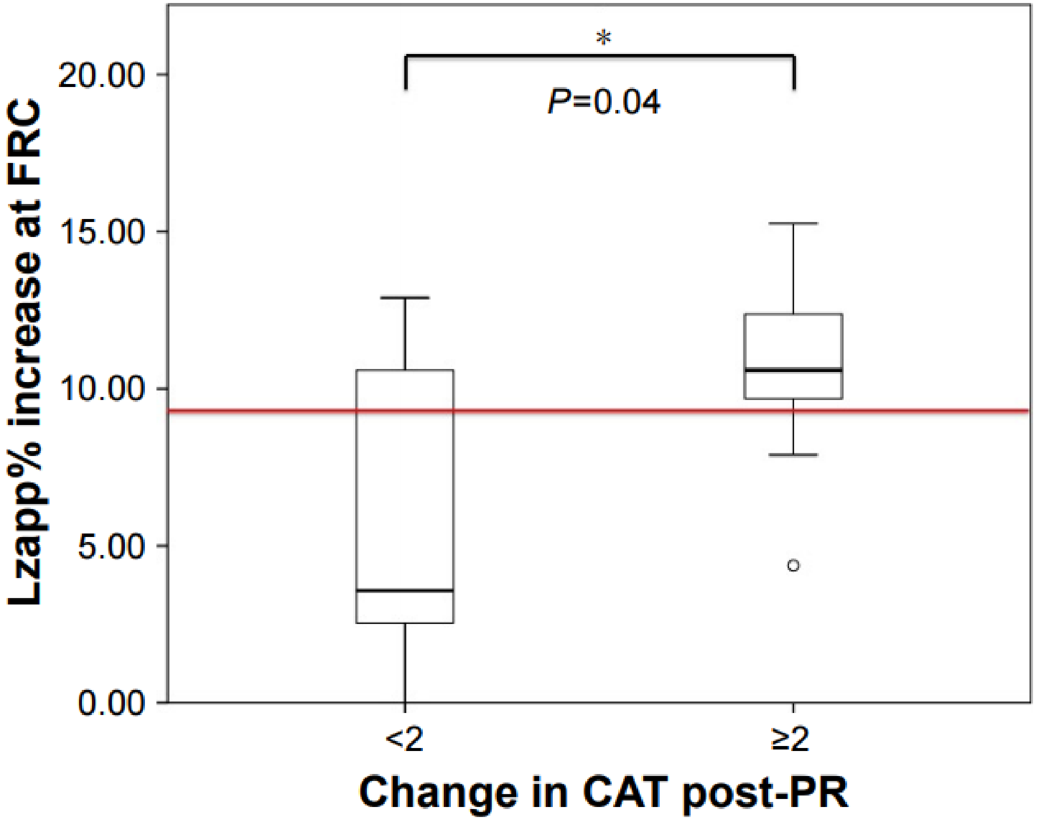
F/U after Pul rehab

International Journal of COPD — Dovepress — open access to scientific and medical research

Open Access Full Text Article — ORIGINAL RESEARCH

Utility of ultrasound assessment of diaphragmatic function before and after pulmonary rehabilitation in COPD patients





D. McKenzie et al. Respiration Physiology 123 (2000):225-234
Crimi et al. IJCOPD 2018:13 3131-3139

Diaphragm dysfunction

- Definition
  - Loss of maximal muscle force generation of diaphragm
  - → ↓Inspiratory capacity, ↓Respiratory muscle endurance

- Mechanism
  - Systemic inflammation; TNF-a, CRP, IL-1 etc.
  - Oxidative stress
  - Hyperinflation by air-trapping
  - Chronic hypoxia
  - Malnutrition

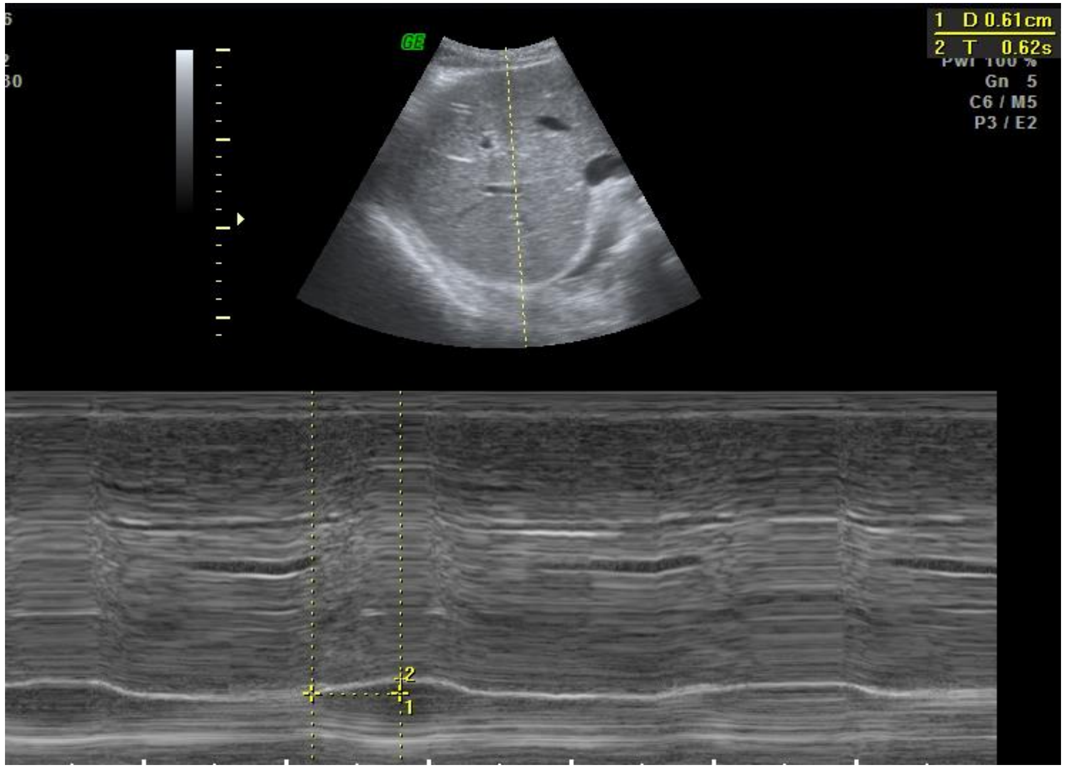
Diaphragm dysfunction

- Evaluation
  - Gold standard – trans-diaphragmatic pressure
  - MIP (maximal static inspiratory pressure), SNIP (sniff inspiratory pressure)
  - EMG (phrenic n. stimulation)
  - Chest radiograph, Fluoroscopy

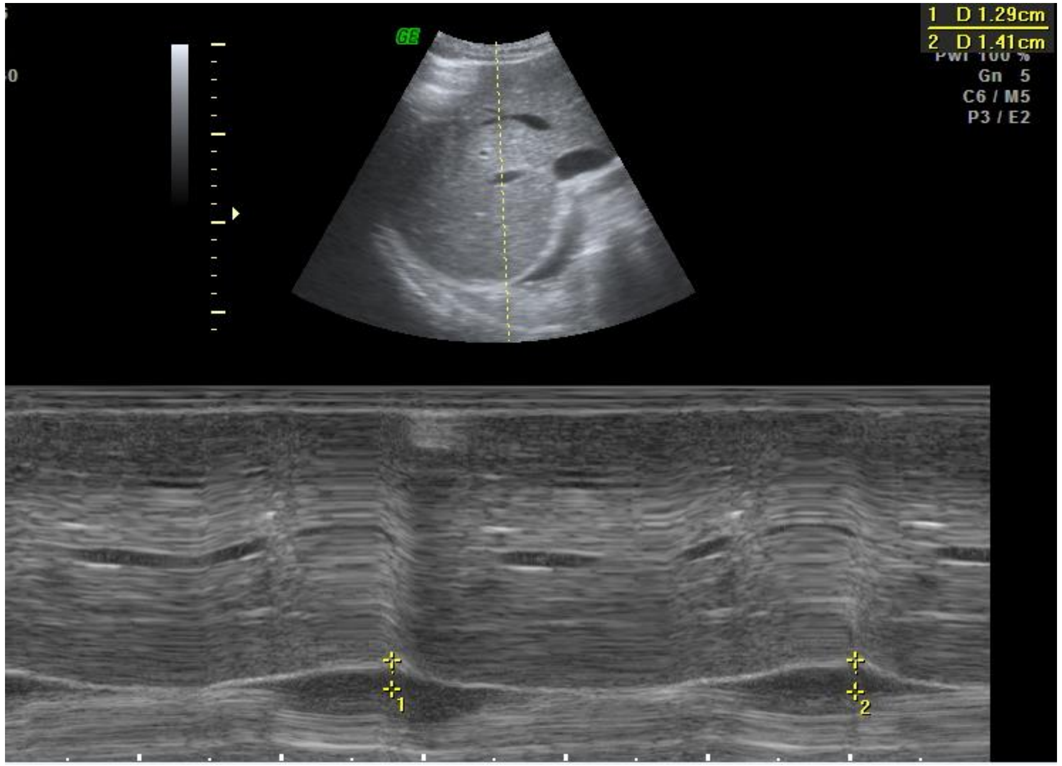
  - **Ultrasound** – non-invasive & real-time visualization

Diaphragm muscle: decreased diaphragm excursion R/O Diaphragm dysfunction

M/73, COPD c AE



Quiet breathing (Rt)



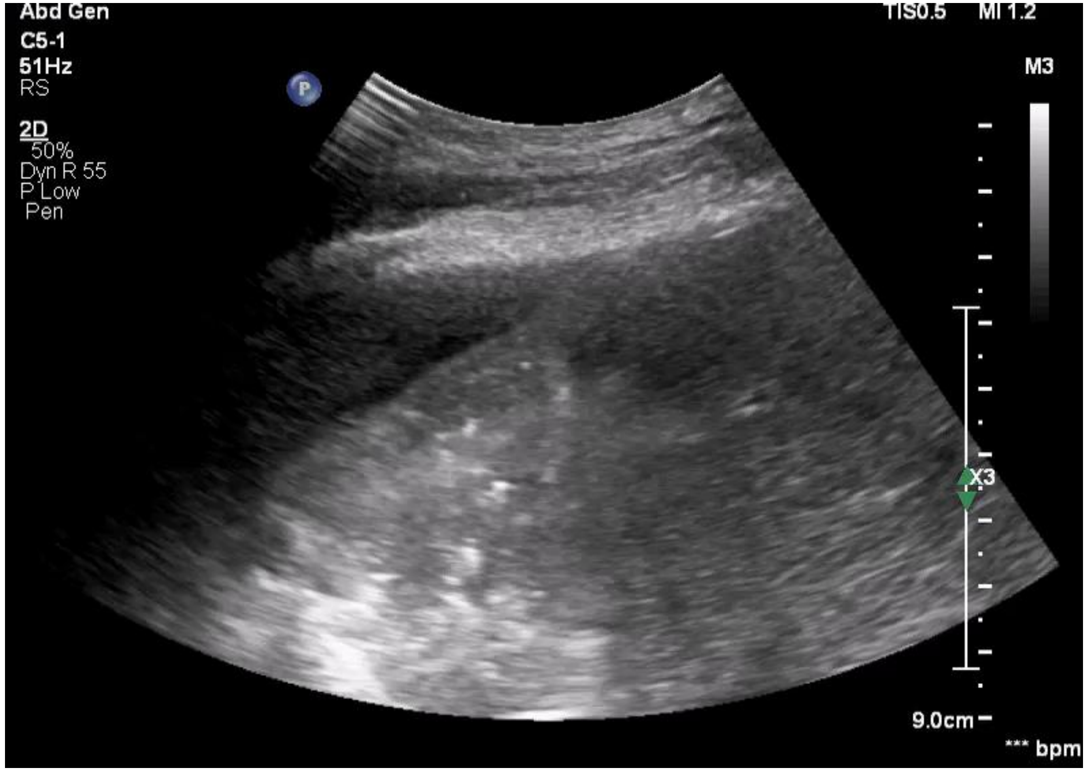
Deep breathing (Rt)

Future plan → diaphragm m. rehab

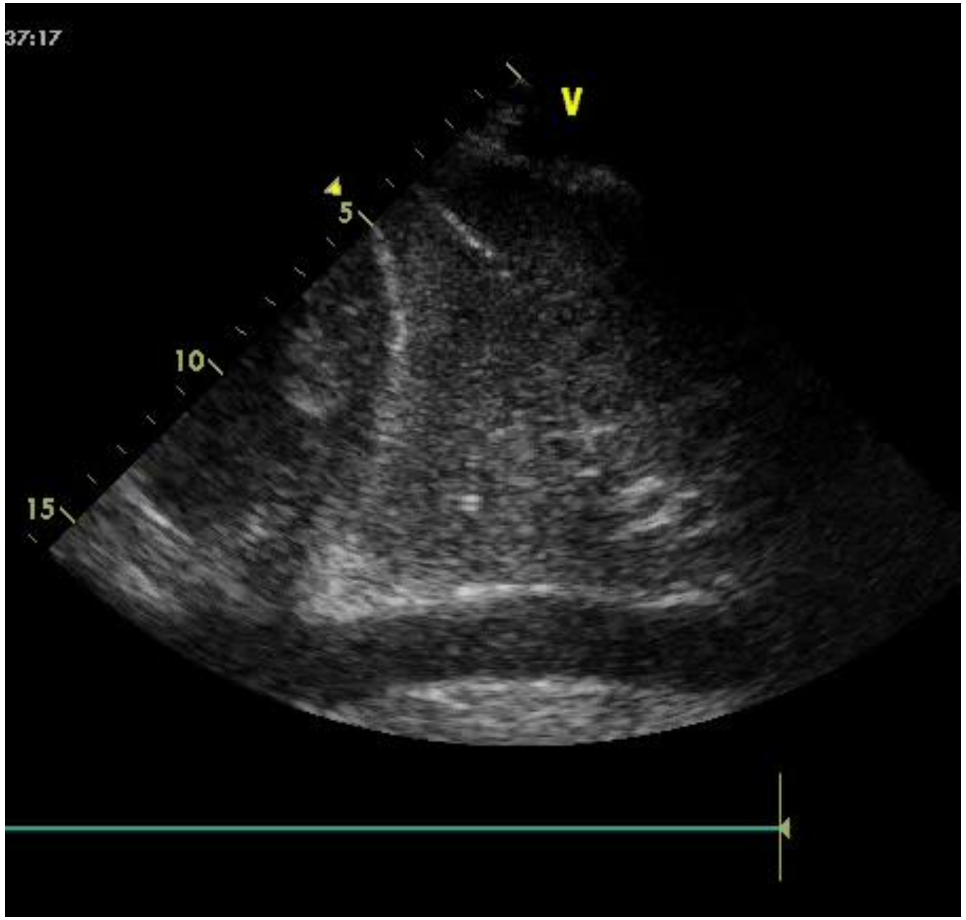
Pneumonia or Atelectasis?

Air-bronchogram

Static air-bronchogram = trapped air

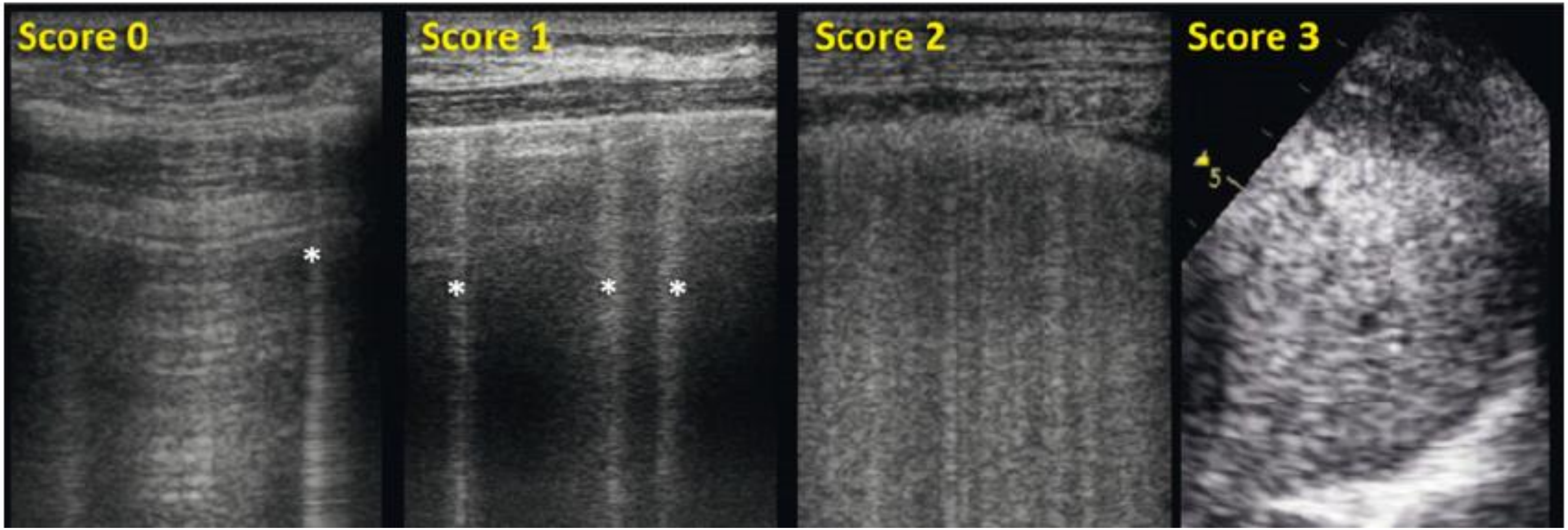


Dynamic air-bronchogram = patent air flow



F Mojoli et al. AJRCCM Vol 199. No 6, March, 2019

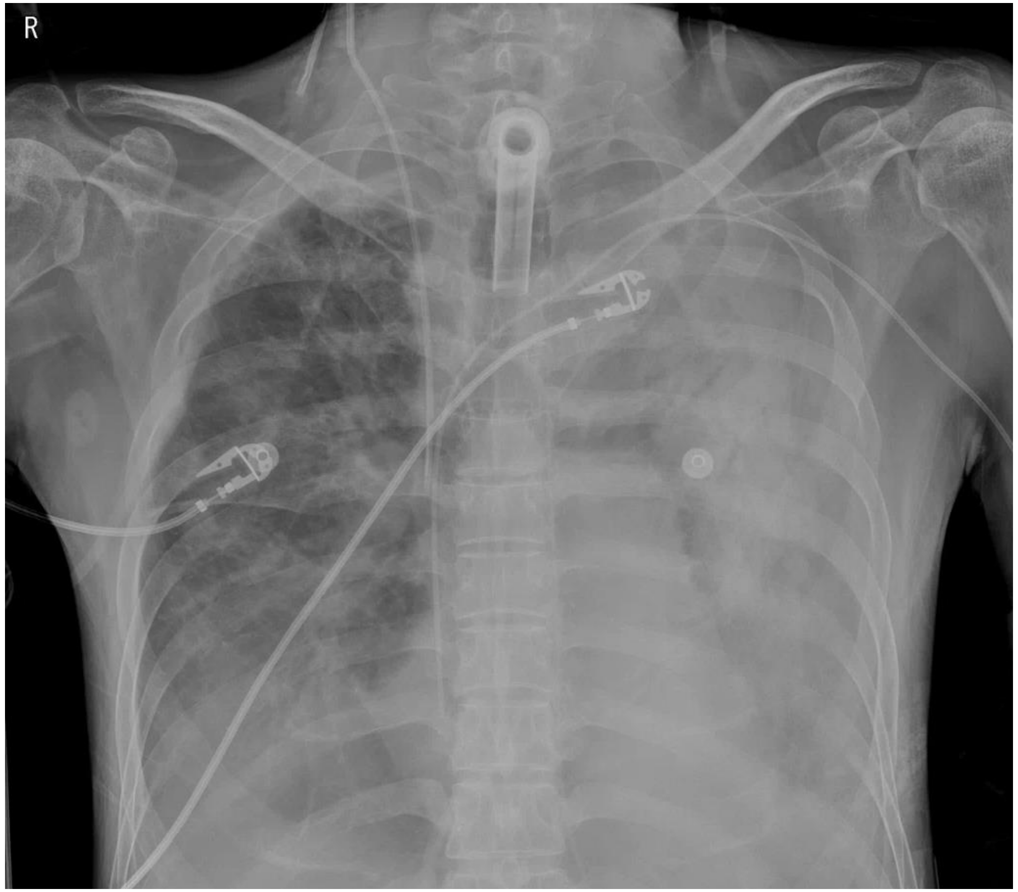
LUS score

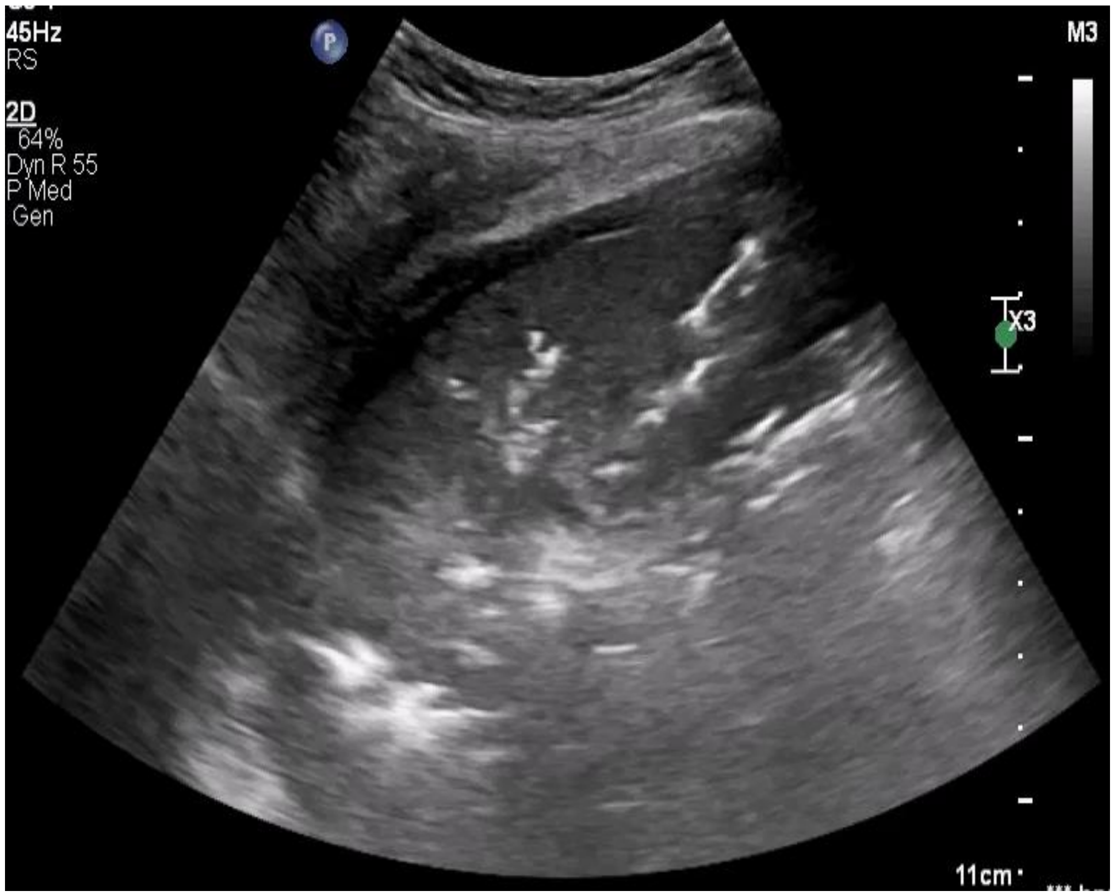


- A-line & B-lines (≤ 2) = normal aeration = score 0
- B-lines (≥ 3) with well-spaced = moderate loss of aeration = score 1
- Coalescent B-lines = severe loss of aeration = score 2
- Tissue-like pattern = complete loss of aeration = score 3

F Mojoli et al. Am J Respir Crit Care Med 2019

Both pneumonia and atelectasis can be possible

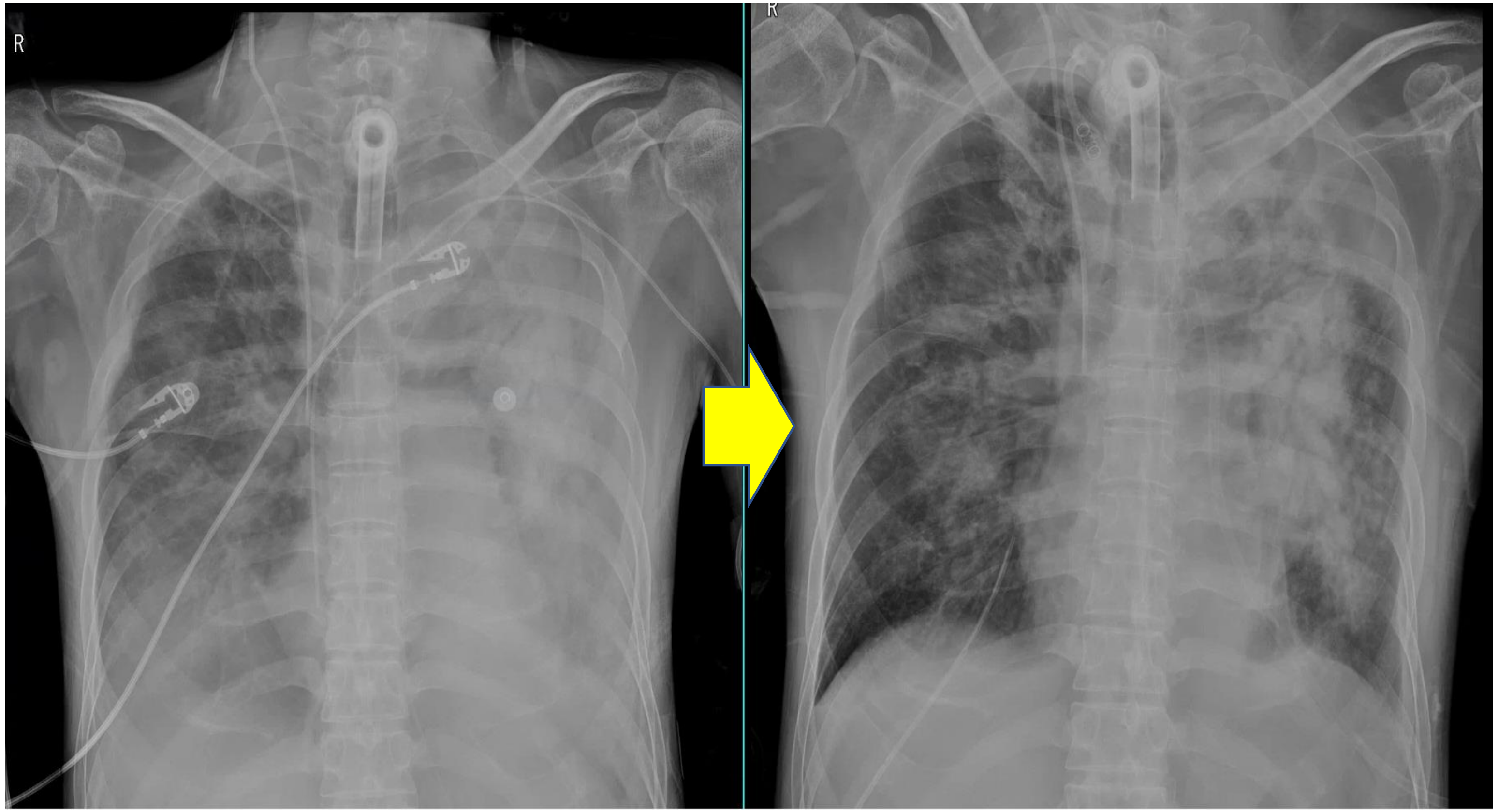


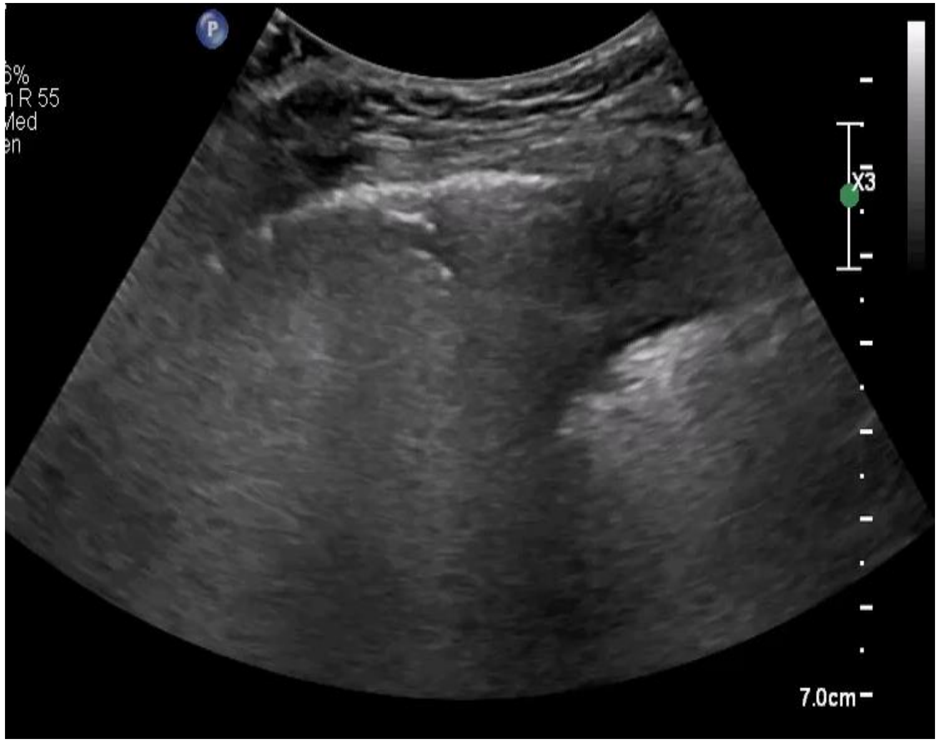


LUS score → 3 점 (complete loss of aeration)

TJ An: 대한내과학회 POCUS 증례

Rapid improvement: atelectasis by mucus plugging





After bronchoscopy → LUS score improved → no need of additional antibiotics changes

TJ An: 대한내과학회 POCUS 증례

COPD and HF: unmet needs

Heart failure, chronic obstructive pulmonary disease, and asthma: numbers, facts, and challenges

Mitja Lainscak[1,2]* and Stefan D. Anker[3]

Table 1 Selected studies investigating comorbid chronic obstructive pulmonary disease and heart failure

Main disease and study	Patients	Comorbidity	Main findings
Heart failure			
Portugal[14]	186 (67 y, 70% men)	COPD 39%	COPD diagnosed with pulmonary function testing in stable out-patients; 23% had severe or very severe COPD; no difference in beta blocker use between COPD and no-COPD (86% vs 88%)
ECHOS-Lung Study group[15]	527 (72 y, 63% men)	COPD 35%	COPD diagnosed with pulmonary function testing in patients admitted with HF: 43% of patients with COPD has self-reported COPD and 33% of patients with self-reported COPD had no COPD; patients with preserved left ventricular ejection fraction have more severe obstruction (Tiffeneau index 0.69 vs 0.74, $p < 0.01$); no difference in beta blocker use between COPD vs no-COPD (27% vs 29%)
Italy[16]	118 (73 y, 86% men)	COPD 30%	COPD diagnosed with pulmonary function Testing in outpatients; 23/36 (64%) patients were unaware of any pulmonary disease; 6% had severe COPD; no difference in beta-blocker use between COPD and no-COPD
Chronic obstructive pulmonary disease			
Italy[17]	218	HF 17%	COPD out-patients with echocardiography; 30/37 patients had left ventricular ejection fraction ≤ 40%
Netherlands[18]	(70 y, 76% men) 405 (73 y, 55% men)	HF 20%	Primary care patients underwent pulmonary function testing and echocardiography; 42/83 patients had systolic HF (32 had left ventricular ejection fraction ≤ 40%), average left ventricular ejection fraction was 45%

ESC Heart Failure 2015; 2: 103–107

COPD and HF : unmet needs

Challenges

Accurate and timely diagnosis of COPD and HF and vice versa remains an unmet need. In stable condition, natriuretic peptides, cardiac imaging, and pulmonary function tests should be performed in patients at risk or with typical symptoms. During acute deterioration, trigger identification is crucial as therapies targeting HF and COPD are to some extent diametrically different and can cause further worsening. The problems with natriuretic peptides were already mentioned thus multimarker strategy was tested. Addition of procalcitonin, D-dimer, and troponin, respectively, to standard laboratory assessment can be helpful for decision taking in emergency room. In the BACH study, a combination of procalcitonin and natriuretic peptides was helpful to qualify patients for antibiotic therapy in cases of pneumonia or pneumonia with heart failure.[29]

A largely neglected imaging method in acutely deteriorated patients is lung ultrasound. Diagnostic performance for excess lung water, pulmonary infarctions, and even pneumonia is remarkable but rarely implemented in clinical practice.[30] With expansion of FOCUS ultrasound, this may change in near future.

ESC Heart Failure 2015; 2: 103–107

BNP and B-lines

BRIEF COMMUNICATIONS

Lung ultrasound B-lines in exacerbations of chronic obstructive pulmonary disease

Krishna B. Sriram[1,2] and Maninder Singh[1,2,3]

[1]Department of Respiratory Medicine, Gold Coast University Hospital, [2]School of Medicine, Griffith University, and [3]School of Medicine, Bond University, Gold Coast, Queensland, Australia

- Perform LUS in AECOPD at Gold Coast University Hospital (2015~2016)
- LUS is sensitive for ↑BNP
- Positive LUS findings = 1> positive LUS scan per hemithorax

Intern Med J . 2017 Mar;47(3):324-327.

BNP and B-lines

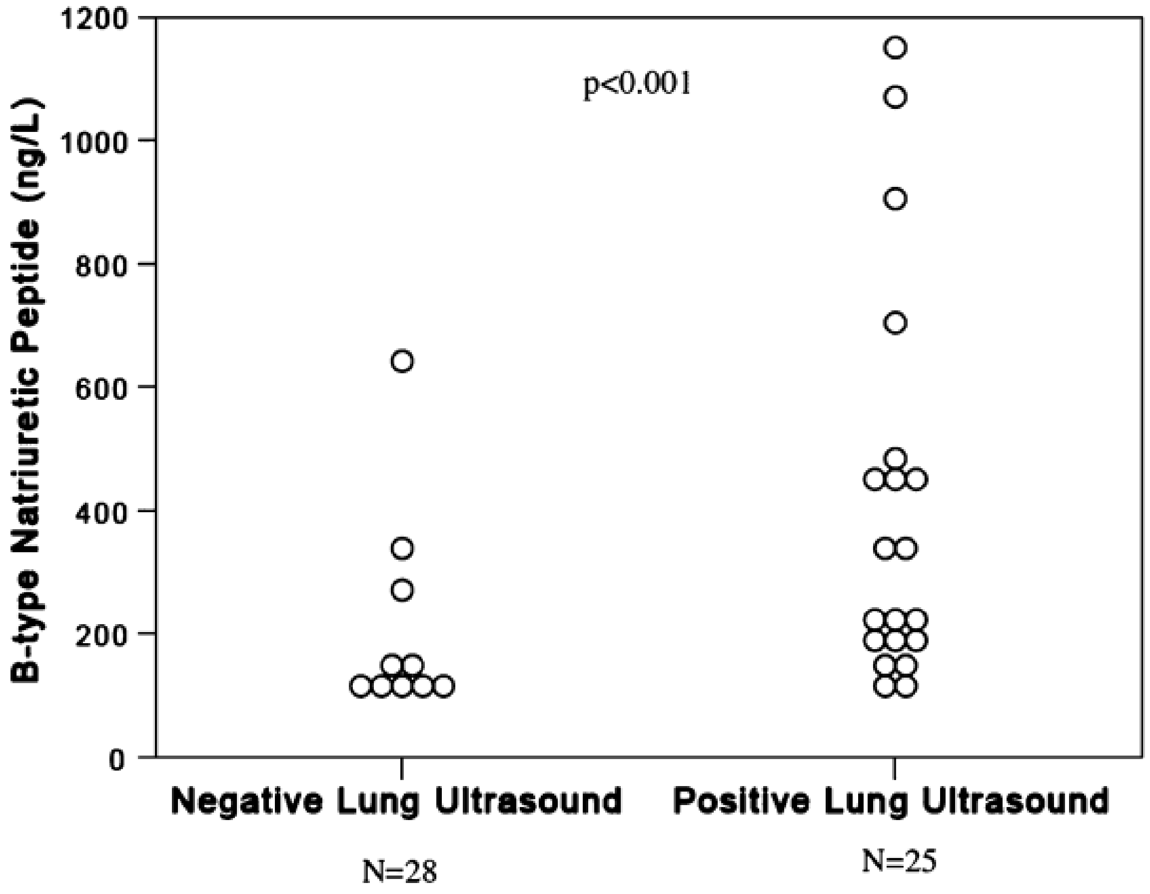


Figure 1 Scatter graph showing plasma concentrations of B-type natriuretic peptide in patients with a positive lung ultrasound study and negative ultrasound study.

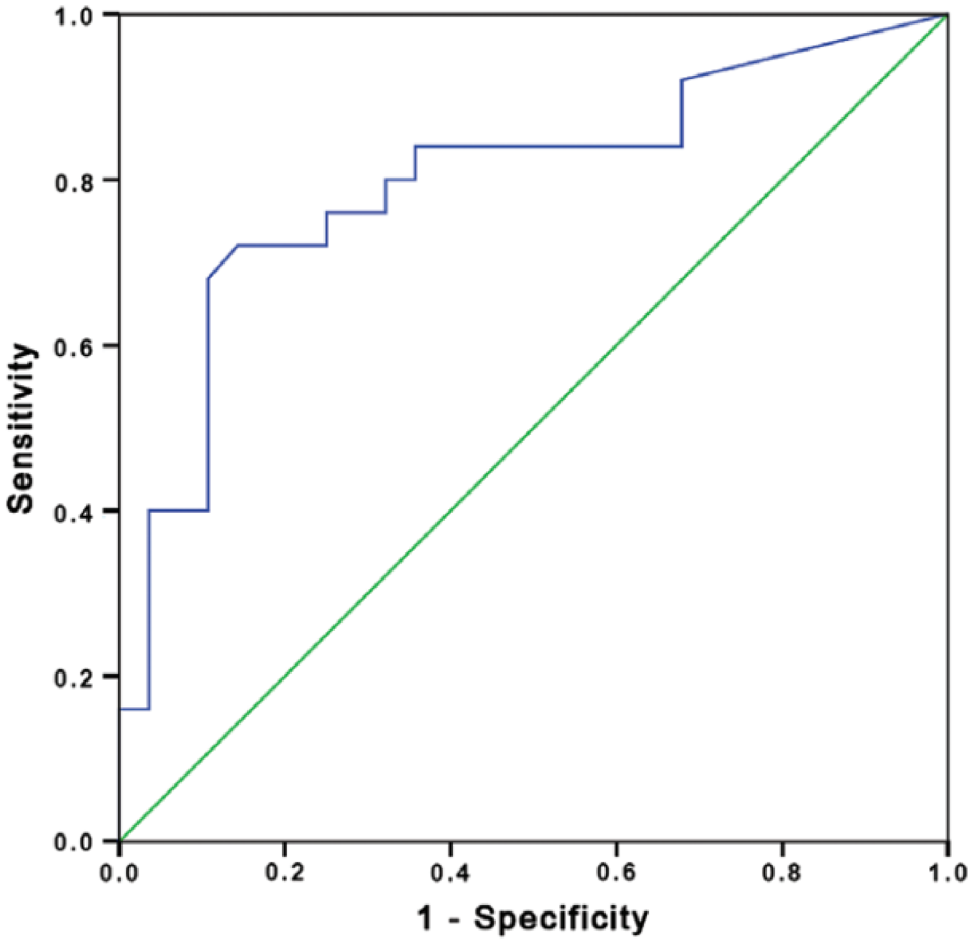


Figure 2 Receiver operator characteristic analysis of B-type natriuretic peptide and lung ultrasound in a cohort of 53 chronic obstructive pulmonary disease patients.

Intern Med J . 2017 Mar;47(3):324-327.

COPD with HF : LUS + BNP

Prosen *et al. Critical Care* 2011, **15**:R114
http://ccforum.com/content/15/2/R114

CRITICAL CARE

RESEARCH Open Access

Combination of lung ultrasound (a comet-tail sign) and N-terminal pro-brain natriuretic peptide in differentiating acute heart failure from chronic obstructive pulmonary disease and asthma as cause of acute dyspnea in prehospital emergency setting

Gregor Prosen[1,2], Petra Klemen[1,2,3], Matej Strnad[1,2] and Štefek Grmec[1,2,3,4*]

ESC Heart Failure 2015; 2: 103–107

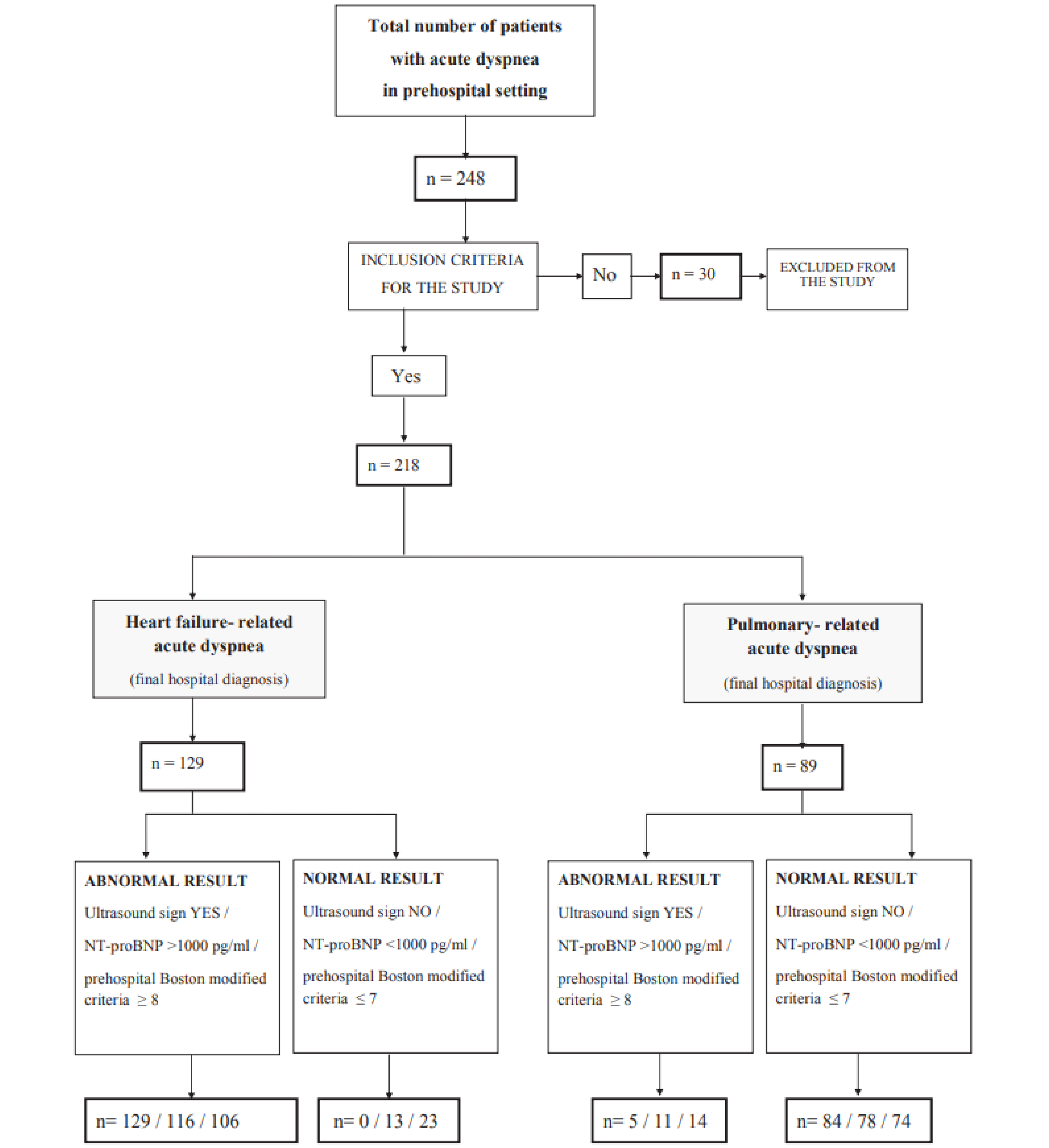


Figure 1 Flow diagram illustrating recruitment, exclusion and subsequent grouping of all patients in the study. NT-proBNP, N-terminal pro-brain natriuretic peptide.

- Prehospital HF-related acute dyspnea by Boston protocol
- Pulmonary-related acute dyspnea
  - Asthma/copd AE definition
  - Boston protocol 5점 이하
- X-ray, LAB, BNP, LUS 시행

COPD with HF : LUS + BNP

Table 3 Multiple logistic regression analysis of factors used for differentiation between HF-related and pulmonary-related acute dyspnea in prehospital emergency setting[a]

Factor	OR (95% CI)[b]	*P* value[c]
Ultrasound examination	53.7 (28.6 to 83.5)	< 0.001
NT-proBNP	14.3 (8.1 to 29.4)	< 0.001
Orthopnea	6.9 (1.9 to 18.39	< 0.001
Rales	5.1 (1.5 to 12.8)	0.014
Troponin T	2.1 (1.3 to 4.6)	0.018
petCO$_2$	7.6 (2.9 to 19.6)	< 0.001
HF medications	2.7 (1.3 to 5.1)	0.031
Asthma/COPD medications	0.12 (0.03 to 0.42)	0.028
Previous HF	7.4 (2.3 to 20.4)	< 0.001
Fever	0.17 (0.06 to 0.49)	0.017

- BNP, LUS after right arrival of ER
- B-line in 8 zone
- Positive = 2+ zone
- proBNP cut off 1000pg/ml

COPD with HF : LUS + BNP

Table 4 Test characteristics of ultrasound examination, modified Boston examination, NT-proBNP and combination of ultrasound examination and NT-proBNP[a]

Characteristic	Ultrasound examination[b]	Modified Boston criteria scoring	NT-proBNP	Ultrasound examination + NT-proBNP[c]	*P* value[d]
Sensitivity	100% (95% CI 98 to 100)	85% (95% CI 79 to 89)	92% (95% CI 88 to 95)	100% (95% CI 98 to 100)	< 0.01
Specificity	95% (95% CI 91 to 100)	86% (95% CI 82 to 90)	89% (95% CI 84 to 92)	100% (95% CI 97 to 100)	< 0.01
NPV	100% (95% CI 98 to 100)	80% (95% CI 77 to 85)	86% (95% CI 82 to 90)	100% (95% CI 98 to 100)	< 0.01
PPV	96% (95% CI 93 to 100)	90% (95% CI 86 to 93)	90% (95% CI 85 to 94)	100% (95% CI 96 to 100)	< 0.01
LR^+	20 (95% CI 1.98 to 89.94)	6.1 (95% CI 1.65 to 18.48)	8.36 (95% CI 1.72 to 33.86)	Infinite	< 0.01
LR^-	0	0.18 (95% CI 0.07 to 0.52)	0.09 (95% CI 0.02 to 0.23)	0	< 0.01
AUROC	0.94 (95% CI: 0.90 to 0.97)	0.86 (95% CI 0.80 to 0.91)	0.90 (95% CI 0.84 to 0.94)	0.99 (95% CI 0.98 to 1.00)	< 0.01

LUS and COPD: systematic review and meta-analysis

Ultrasound in Emergency Medicine

LUNG ULTRASOUND FOR THE EMERGENCY DIAGNOSIS OF PNEUMONIA HEART FAILURE, AND EXACERBATIONS OF CHRONIC OBSTRUCTI PULMONARY DISEASE/ASTHMA IN ADULTS: A SYSTEMATIC REVIEW META-ANALYSIS

Leonardo Jönck Staub, MD, PHD,* Roberta Rodolfo Mazzali Biscaro, MSC,† Erikson Kaszubowski, Rosemeri Maurici, MD, PHD§||

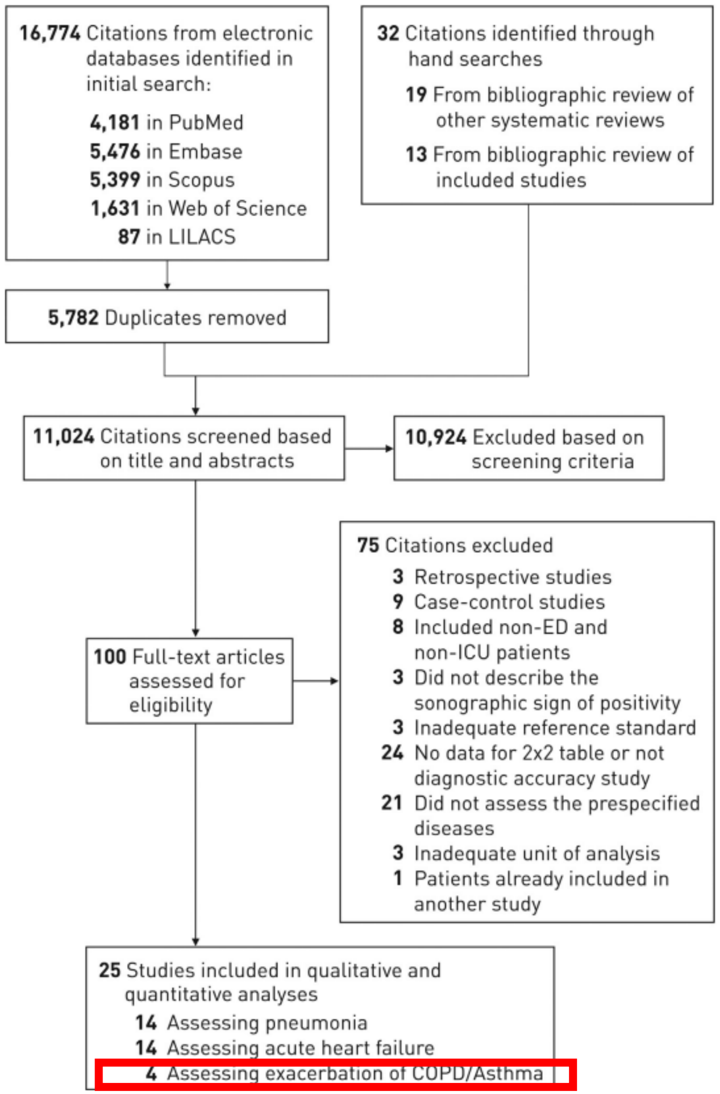


Figure 1. Flow diagram of study selection process. *Some studies assessed more than one target disease. LILACS = Literatura Latino Americana e do Caribe em Ciências da Saúde; ED = emergency department; ICU = intensive care unit; COPD = chronic obstructive pulmonary disease.

The Journal of Emergency Medicine, Vol. 56, No. 1

LUS and COPD: systematic review and meta-analysis

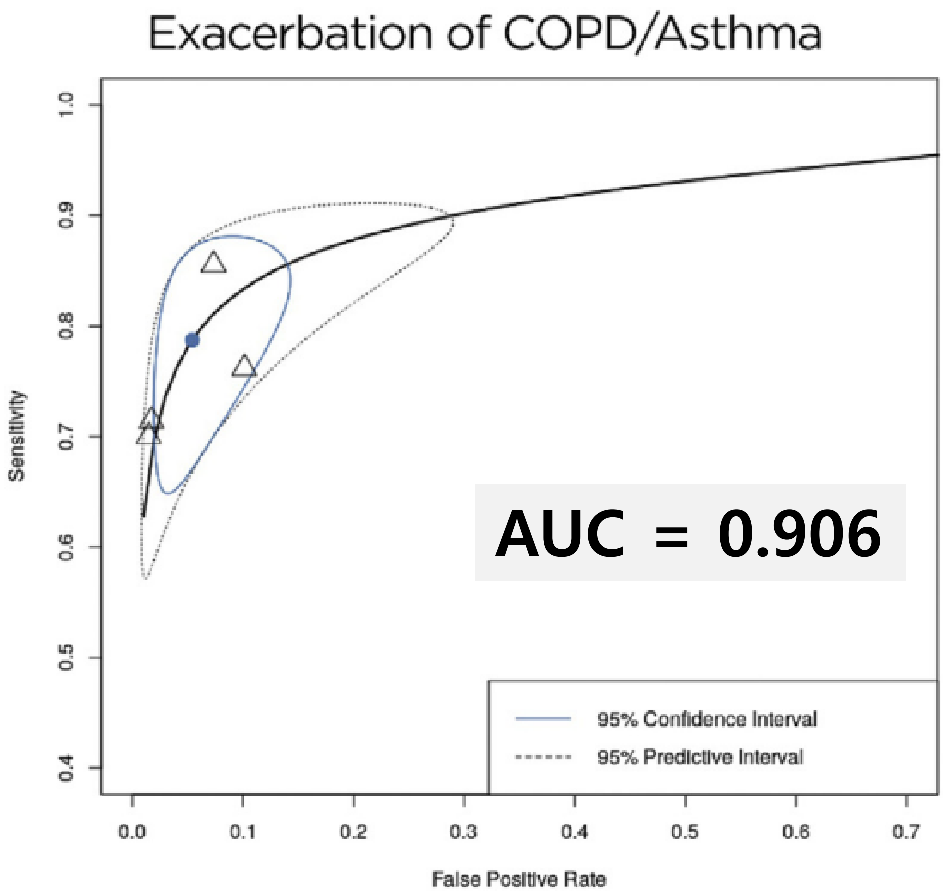


Figure 3. Hierarchical summary receiver operating characteristic (HSROC) curves for overall diagnostic accuracy of lung ultrasound for pneumonia, acute heart failure, and for exacerbations of chronic obstructive pulmonary disease (COPD)/asthma. AUC = area under the curve.

The Journal of Emergency Medicine, Vol. 56, No. 1

LUS and COPD: systematic review and meta-analysis

Table 5. Diagnostic Accuracy of Lung Ultrasonography* for Exacerbation of COPD/Asthma†

Source	Included Patients	Confirmed and Total Analyzed	Sensitivity (95% CI)	Specificity (95% CI)	Positive LR (95% CI)	Negative LR (95% CI)
Daabis et al., 2014 (18)	Respiratory failure	21/100	0.76 (0.54–0.89)	0.89 (0.81–0.94)	7.52 (3.74–15.14)	0.26 (0.12–0.57)
Dexheimer et al., 2015 (19)	Respiratory failure	4/37	0.70 (0.29–0.92)	0.98 (0.87–0.99)	47.6 (2.86–791.1)	0.30 (0.07–1.16)
Gallard et al., 2015 (20)	Acute dyspnea	14/130	0.71 (0.45–0.88)	0.98 (0.93–0.99)	41.43 (10.1–170.2)	0.29 (0.12–0.66)
Lichtenstein et al., 2008 (21)	Respiratory failure	83/260	0.85 (0.76–0.91)	0.92 (0.87–0.95)	11.65 (6.85–19.8)	0.15 (0.09–0.26)
Summary	Respiratory failure or acute dyspnea	122/527	0.78 (0.67–0.86)	0.94 (0.89–0.97)	14.57 (5.70–40.25)	0.22 (0.13–0.36)

COPD = chronic obstructive pulmonary disease; LR = likelihood ratio; CI = confidence interval.
* The A-profile without PLAPS was the only sonographic pattern assessed. It consists in the predominance of A lines and presence of lung sliding in anterior chest areas and absence of consolidation and pleural effusion in posterior lateral areas.
† All studies used the final diagnosis as the reference standard.

ERS statement on chest imaging in acute respiratory failure

Davide Chiumello[1,2], Giuseppe Francesco Sferrazza Papa[3], Antonio Artigas[4,5], Belaid Bouhemad[6], Aleksandar Grgic[7], Leo Heunks[8], Klaus Markstaller[9], Giulia M. Pellegrino[2,3], Lara Pisani[10], David Rigau[11], Marcus J. Schultz[12], Giovanni Sotgiu[13], Peter Spieth[14,15], Maurizio Zompatori[16] and Paolo Navalesi[17]

ERS statement

Ultrasound

The studies on LU used to prepare this statement are listed in table 2. Because the ultrasound beam does not penetrate the lung, LU is able to explore only the pleural line and the related artefacts that are generated at the pleural line. The pleural line appears as a hyperechoic sliding line, moving forwards and backwards in the course of inspiration and expiration. The key artefacts are A- and B-lines. B-lines correspond to various degrees of lung aeration and the quantity is related to the amount of extravascular lung water. Multiple and well-separated vertical B-lines correspond to a moderate decrease in lung aeration resulting from interstitial syndrome. Coalescent B-lines correspond to a more severe decrease in lung aeration resulting from partial filling of alveolar spaces by pulmonary oedema or confluent bronchopneumonia. Lung consolidation is a tissue-like echotexture pattern due to a loss of aeration of lung parenchyma [18].

ERS statement

COPD

In COPD patients, acute exacerbation usually shows a normal LU pattern despite the presence of acute respiratory failure. On the contrary, the presence of B-lines suggests the presence of an associated alveolar interstitial syndrome with an acceptable accuracy [40]. Chest ultrasonography (heart and lung) in patients admitted with acute respiratory failure allows a more accurate diagnosis of decompensated COPD compared to a standard diagnostic approach, based on physical examination, CXR and biological data [41].

Reimbursement

Current reimbursement of LUS in Korea

- **Thorax Ultrasound: LUS + others**
- “유방액와부, 흉벽, 흉막, 늑골 등”
- “해부학적 구조 이상을 진단하거나, 경과관찰하기 위하여“
- “의사가 직접 시행”
- “**2021**년 **4**월 **1**일부터 시행한다 "

Current reimbursement of LUS in Korea

제2부 제2장 검사료 제5절 초음파 검사료 [진단초음파] '나-942 흉부'를 다음과 같이 변경 및 신설한다.

분류번호	코 드	분 류	점 수
		[진단초음파]	
나-942		흉부	
		가. 유방·액와부 초음파 Breast·Axilla Ultrasonography	
		주 : 「(1) 또는 (2)」와 「(3)」을 동일에 실시한 경우에는 주된 항목의 소정점수만 산정한다.	
	EB421	(1) 일반 General	1,037.52
	EB423	(2) 정밀 Detailed	1,452.53
	EB424	(3) 자동유방초음파 Automated Breast Ultrasound	759.66
	EB422	나. 흉벽, 흉막, 늑골 등 초음파 Chest Wall, Pleura, Rib, etc Ultrasonography	717.59

- 급여초음파의 구분
  - 진단초음파
    - 해부학적 부위확인 전부: 판독 소견서 필요, 표준 영상항목 시행
    - 제한적 초음파: 진단초음파 이후 경과 관찰
  - 기본초음파(단순초음파): 일부부위

Current reimbursement of LUS in Korea

- **EB401 단순초음파(1)**
  - 진단시 보조 역할
  - 수술, 시술후 혈종 확인
  - 종물 또는 종양 크기 확인
  - 수술부위 피부위치 표시
  - 장기크기 측정 등

Current reimbursement of LUS in Korea

- **EB402 단순초음파(II)**
  - 진단 초음파의 해부학적 부위 상태 모두 확인이 아닌 일부만 확인하기 위해 시행
  - 처치, 시술 진행시 보조역할
  - 천자부위 위치 확인
  - 카테터 삽입부위 위치확인

Current reimbursement of LUS in Korea

- 유도초음파
  - 암 또는 암 의심 환자는 급여
  - 양성병변의 조직검사, **abscess**의 **aspiration** 은 비급여
  - **C8040:** 흉막천자
    - **O1510** 흉강삽관술(폐쇄식)
    - **M6741:** 경피적튜브배액술

→ 현 보험 요건상 **fluoroscopy** 없이 시행하면 대부분 **C8040** 만 가능한 상태

Current reimbursement of LUS in Korea

- 진단초음파의 표준 영상 (진단 초음파의 해부학적 부위 상태 모두 확인이 아닌 일부만 확인하기 위해 시행)

1) 표준영상의 범위

가) 흉벽, 흉막 등

좌·우측 각각의 전면 및 측면 흉곽을 4개 이상의 구역으로 나누어 각 구역의 횡스캔, 종스캔 또는 시상면 스캔. 필요시 후면 흉곽을 2개 구역으로 나누어 각 구역의 횡스캔, 종스캔 또는 시상면 스캔

나) 늑골 등

통증이 있어 늑골 골절이 의심되는 부위의 늑골 횡스캔, 종스캔 또는 시상면 스캔, 반대측 같은 부위 늑골 횡스캔, 종스캔 또는 시상면 스캔, 통증 부위 늑골주변 연부조직 횡스캔, 종스캔 또는 시상면 스캔, 필요시 흉골 골절 의심부위를 포함한 흉골 횡스캔, 종스캔 또는 시상면 스캔

Current reimbursement of LUS in Korea

- 진단초음파의 표준 영상 (진단 초음파의 해부학적 부위 상태 모두 확인이 아닌 일부만 확인하기 위해 시행)

2) 판독소견서

가) 등록번호, 성명, 생년월일 또는 나이, 성별, 검사명, 검사일시, 판독일시, 검사와 판독한 의사(면허번호), 검사소견, 결론, 의료기관명

나) 검사소견

(1) 흉벽, 흉막 등

기흉의 유무, 기흉의 위치, 흉수의 유무, 흉수의 양과 위치, 흉수의 성상, 흉벽, 흉막 내 국소병변 유무, 국소병변의 크기, 위치, 초음파 특성, 흉막 두께의 이상 유무를 포함해야 하며 이상소견이 있는 경우 세부내용을 상세 기술해야 함

(2) 늑골 등

늑골 골절의 유무, 늑골 골절을 시사하는 간접소견의 유무, 늑골 전위(Displacement)의 정도, 늑골 골절과 동반된 이상소견을 상세 기술해야 함

Current reimbursement of LUS in Korea

- 산정횟수
  - 에피소드당 1회
  - 동일 부위 동일 상병이라도,

    증상 변화, 치료 종료, 재발 등 의학적 판단에 따라 별개 에피소드 가능.
  - 단 30일 이내에는 같은 에피소드로 간주

KATRD 흉부초음파 TF 에서 개발중인 판독지

KATRD Chest (Lung) US Report

Patient Details: ID ___________ Name ________ Age (   ) yrs M☐ / F☐

Date: YYYY-MM-DD

Clinical Indication:

☐Chest wall ☐Pleura ☐Rib

☐Parenchyma and others

[☐Dyspnea ☐Hypoxemia ☐Procedure (Intubation/Catheter/TBLB) ☐Other: ________]

Study details: ____

Findings:

Airway	☐not deviated and (______________________________)	
	Right	Left
Chest wall		
Area 1	☐n/a ☐abnormal (________)	☐n/a ☐abnormal (________)
Area 2	☐n/a ☐abnormal (________)	☐n/a ☐abnormal (________)
Area 3	☐n/a ☐abnormal (________)	☐n/a ☐abnormal (________)
Area 4	☐n/a ☐abnormal (________)	☐n/a ☐abnormal (________)
Rib fractures	☐n/a ☐abnormal (________ th)	☐n/a ☐abnormal (________ th)

Current reimbursement of LUS in K...

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Pleura		
Lung Sliding Area 1	□Yes (□Lung pulse) □No (□Lung point: ____ cm) M-mode: (__________________)	□Yes (□Lung pulse) □No (□Lung point: ____ cm) M-mode: (__________________)
Area 2	□Yes (□Lung pulse) □No (□Lung point: ____ cm) M-mode: (__________________)	□Yes (□Lung pulse) □No (□Lung point: ____ cm) M-mode: (__________________)
Area 3	□Yes (□Lung pulse) □No (□Lung point: ____ cm) M-mode: (__________________)	□Yes (□Lung pulse) □No (□Lung point: ____ cm) M-mode: (__________________)
Area 4	□Yes (□Lung pulse) □No (□Lung point: ____ cm) M-mode: (__________________)	□Yes (□Lung pulse) □No (□Lung point: ____ cm) M-mode: (__________________)
Pleural effusion	□Y (PLD_{base} : _____ cm) □N □Transudate □Exudate □Septated □Thickening: ____ mm □Nodules: Y / N	□Y (PLD_{base} : _____ cm) □N □Transudate □Exudate □Septated □Thickening: ___ mm □Nodules: Y / N

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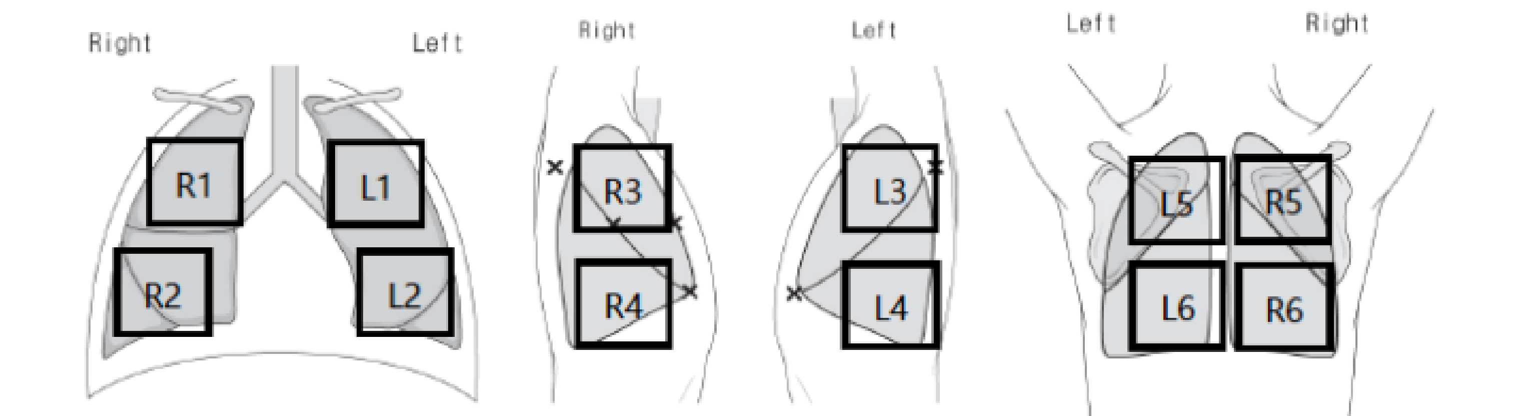

Lung parenchyma		
Area 1 (Lines)	☐ A ☐ B1 ☐ B2 ☐ C	☐ A ☐ B1 ☐ B2 ☐ C
Area 2 (Lines)	☐ A ☐ B1 ☐ B2 ☐ C	☐ A ☐ B1 ☐ B2 ☐ C
Area 3 (Lines)	☐ A ☐ B1 ☐ B2 ☐ C	☐ A ☐ B1 ☐ B2 ☐ C
Area 4 (Lines)	☐ A ☐ B1 ☐ B2 ☐ C	☐ A ☐ B1 ☐ B2 ☐ C
Lung score	(___)	(___)
PLAPS	☐ Y ☐ N	☐ Y ☐ N
Profile by BLUE	☐ A ☐ A' ☐ B ☐ B' ☐ A/B	☐ A ☐ A' ☐ B ☐ B' ☐ A/B
(Optional)		
Area 5 (Lines)	☐ A ☐ B1 ☐ B2 ☐ C	☐ A ☐ B1 ☐ B2 ☐ C
Area 6 (Lines)	☐ A ☐ B1 ☐ B2 ☐ C	☐ A ☐ B1 ☐ B2 ☐ C

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Diaphragm* Excursion Thickness	☐ Y (M-mode : ____ mm) ☐ N Insp ___ mm / Exp ___ mm (Δ___%)	☐ Y (M-mode : ____ mm) ☐ N Insp ___ mm / Exp ___ mm (Δ___%)
Free text:		
Conclusion:		
Assesses by F. ________ / Pf. ________		

* Maximal deep breathing

Summary of LUS in COPD

- Lung is suitable for ultrasound. COPD is also same
- LUS
  - Interpretation of artifacts
  - A-line : long path reverberation artifact, means good aeration
  - B-line : short path reverberation artifact, means interstitial syndrome
  - It helps ddx other conditions, such as HF (LUS+BNP), pneumothorax (Lung point), and pleural effusion etc.

Summary of LUS in COPD

- Diaphragm US
  - Only way of real-time evaluation of diaphragm
  - Easy way of measuring diaphragm function
  - DDx healthy vs COPD
  - Associated with COPD lung functions
  - DDx stable vs. AECOPD
  - Associated with pul rehab outcomes

Thank you for your attention

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