



# Lung ultrasound in Internal Medicine: Clinical applications and clinical cases

Luna Gargani



Cardiology Department Institute of Clinical Physiology National Council of Research, Pisa, Italy

Gent, 22<sup>nd</sup> November 2014

# **Clinical applications**

### 1. Heart Failure

- Diagnosis
- Follow-up
- Prognosis
- 2. ARDS

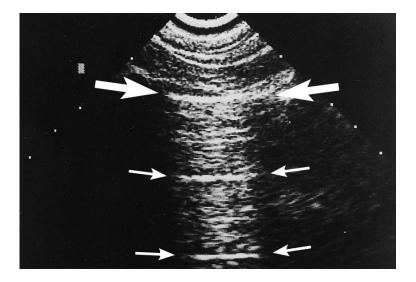
3. Pneumonia (consolidations)

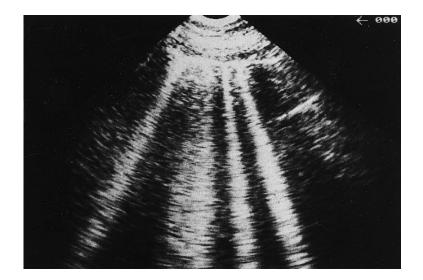
4. Dialysis

5. Pulmonary fibrosis

#### BRIEF REPORT

D. Lichtenstein G. Mezière A lung ultrasound sign allowing bedside distinction between pulmonary edema and COPD: the comet-tail artifact





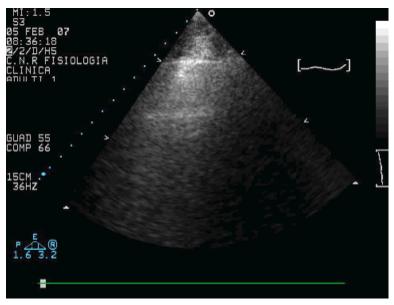
### **Exacerbation of COPD**

### Acute pulmonary oedema

#### BRIEF REPORT

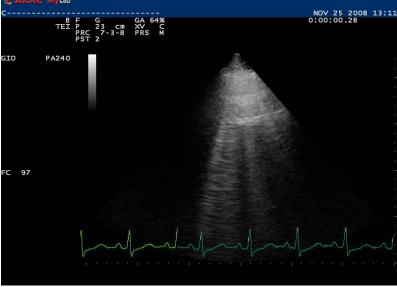
D. Lichtenstein G. Mezière A lung ultrasound sign allowing bedside distinction between pulmonary edema and COPD: the comet-tail artifact

### **No B-lines**



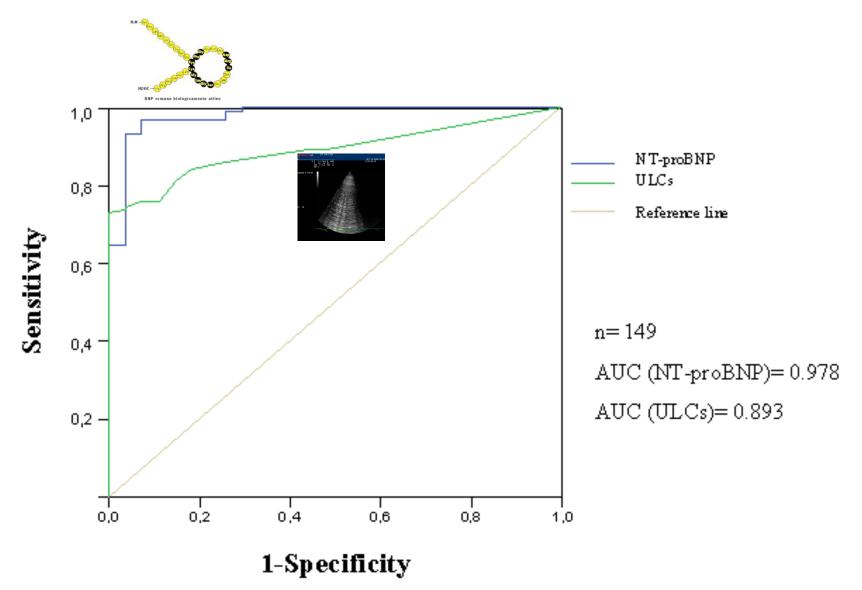
**Exacerbation of COPD** 

# Multiple B-lines



### Acute pulmonary oedema

### **B-lines and natriuretics peptides**



Gargani L, Picano E. Eur J Heart Fail 2008;10:70-7.

### **B-lines at the emergency department**

Emergency Thoracic Ultrasound in the Differentiation of the Etiology of Shortness of Breath (ETUDES): Sonographic B-lines and N-terminal Pro-brain-type Natriuretic Peptide in Diagnosing Congestive Heart Failure

Andrew S. Liteplo, MD, RDMS, Keith A. Marill, MD, Tomas Villen, MD, Robert M. Miller, MD, Alice F. Murray, MBChB, Peter E. Croft, BS, Roberta Capp, MD, and Vicki E. Noble, MD, RDMS

#### RESEARCH

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<sup>1,2</sup>, Petra Klemen<sup>1,2,3</sup>, Matej Strnad<sup>1,2</sup> and Štefek Grmec<sup>1,2,3,4\*</sup>

Intern Emerg Med DOI 10.1007/s11739-011-0709-1

**EM - ORIGINAL** 

#### Diagnostic accuracy and reproducibility of pleural and lung ultrasound in discriminating cardiogenic causes of acute dyspnea in the Emergency Department

Gian Alfonso Cibinel · Giovanna Casoli · Fabrizio Elia · Monica Padoan · Emanuele Pivetta · Enrico Lupia · Alberto Goffi



**Open Access** 

### Emergency echocardiography: the European Association of Cardiovascular Imaging recommendations

Aleksandar N. Neskovic<sup>1</sup>\*, Andreas Hagendorff<sup>2</sup>, Patrizio Lancellotti<sup>3</sup>, Fabio Guarracino<sup>4</sup>, Albert Varga<sup>5</sup>, Bernard Cosyns<sup>6</sup>, Frank A. Flachskampf<sup>7</sup>, Bogdan A. Popescu<sup>8</sup>, Luna Gargani<sup>9</sup>, Jose Luis Zamorano<sup>10</sup>, and Luigi P. Badano<sup>11</sup>, on behalf of the European Association of Cardiovascular Imaging<sup>†</sup>

### Lung ultrasound examination

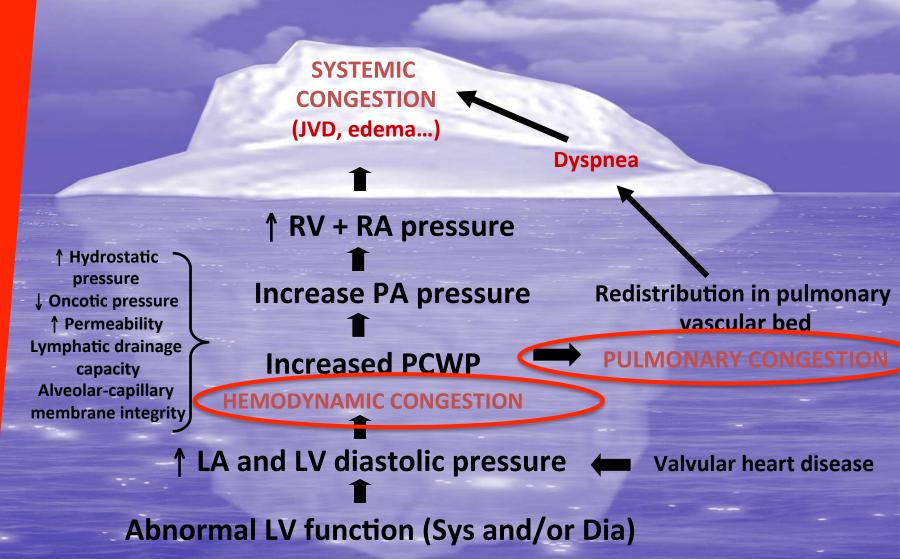
In recent years, lung ultrasound (LUS) has been proposed as a useful point-of-care tool in emergency.  $^{25}$ 

The LUS examination can be performed with any commercially available 2-D scanner, including pocket-size devices, by using a cardiac, convex or microconvex transducer, with the patient in the near-supine, supine, sitting, or even standing position.

In addition to the detection of pleural effusion, LUS may help in the diagnosis of acute dysphoea, allowing the differential identification of pneumothorax, pulmonary consolidations, acute respiratory distress syndrome, and cardiogenic pulmonary oedema.<sup>25</sup>

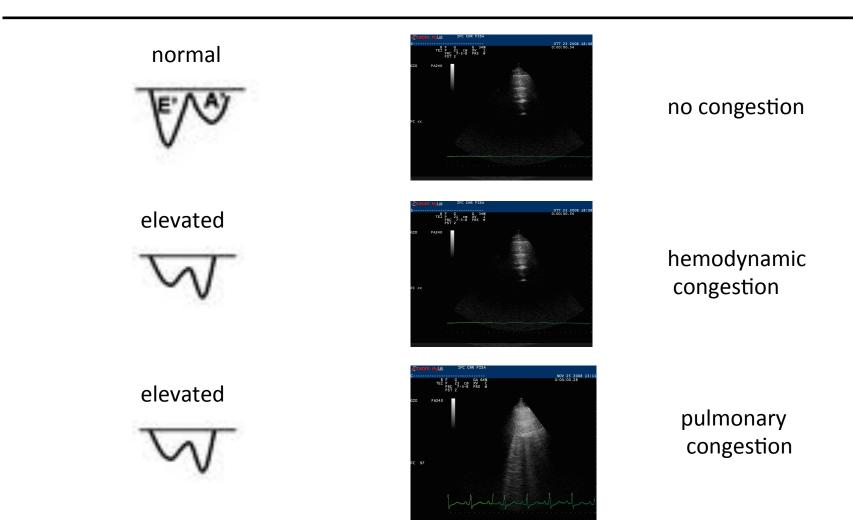
The absence of multiple bilateral B-lines, a sign of increased extravascular lung water, excludes cardiogenic pulmonary oedema with a negative predictive value close to 100%.<sup>26</sup>

# **The Congestion Iceberg in Heart Failure**



Modified by Gheorghiade M et al. Eur J Heart Fail 2010;12:423-33.

# Hemodynamic vs pulmonary congestion



Gargani L. Cardiovascular Ultrasound 2011;9:6.

# **Clinical applications**

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  - Prognosis
- 2. ARDS

3. Pneumonia (consolidations)

4. Dialysis

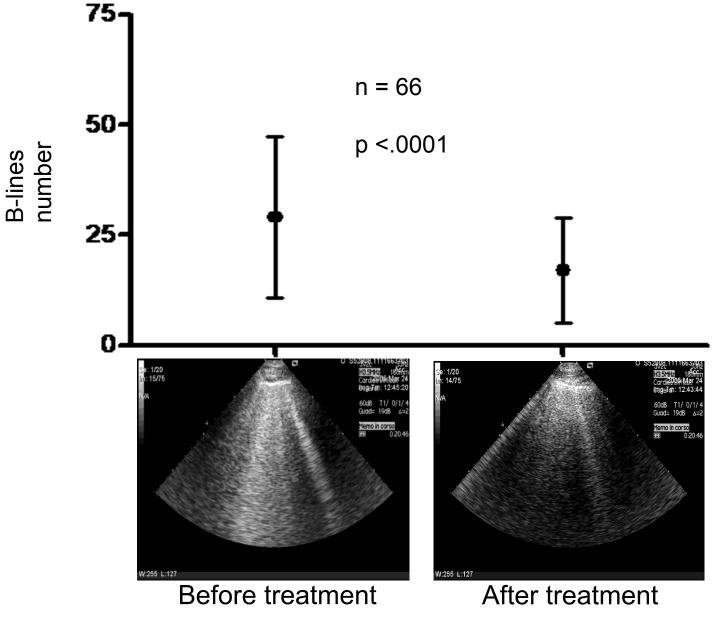
5. Pulmonary fibrosis

# **Acute heart failure**

individualizable thoracic areas at admission (phase 1) and control (phase 2) in 70 patients admitted for ADHN				
Thoracic area	Phase 1 <sup>a</sup>		Phase 2 <sup>a</sup>	P(W)
Anterior superior right	51 (73%)		3 (4.3%)	<.001
Anterior medium right	54 (77%)		2 (2.9%)	<.001
Anterior basal right	65 (93%)	М	4 (5.7%)	<.001
Lateral superior right	64 (91%)	М	5 (7.1%)	<.001
Lateral medium right	67 (96%)		10 (14%)	<.001
Lateral basal right	68 (97%)	П	21 (30%)	<.001
Anterior superior left	52 (74%)	П	6 (8.6%)	<.001
Anterior medium left	58 (83%)		6 (8.6%)	<.001
Lateral superior left	63 (90%)		6 (8.6%)	<.001
Lateral medium left	70 (100%)		11 (16%)	<.001
Lateral basal left	70 (100%)		20 (29%)	<.001
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Table 6 Positive ultrasound lung scope in the 11

### Furosemide stress test



Gargani L, Frassi F, Picano E, et al. Eur J Echocardiogr 2005 (December supplement)

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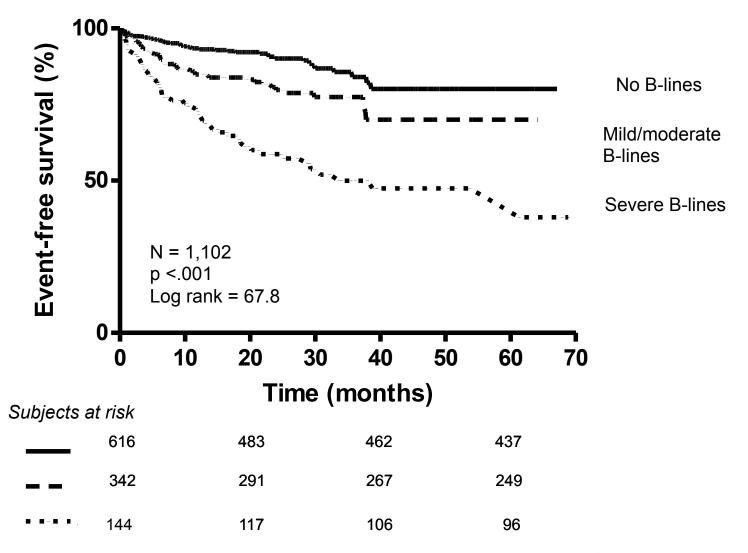
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5. Pulmonary fibrosis

# **Prognosis in cardiac patients**

206 events (death, AMI, decompensated heart failure)



Gargani L, Picano E et al. ESC Congress 2010

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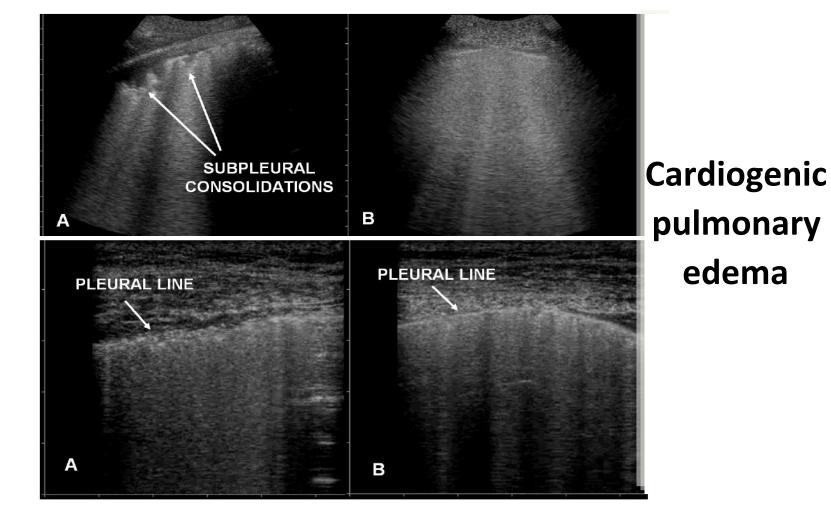
4. Dialysis

5. Pulmonary fibrosis

### **Cardiogenic edema vs ARDS**

### SUB-PLEURAL ALTERATIONS

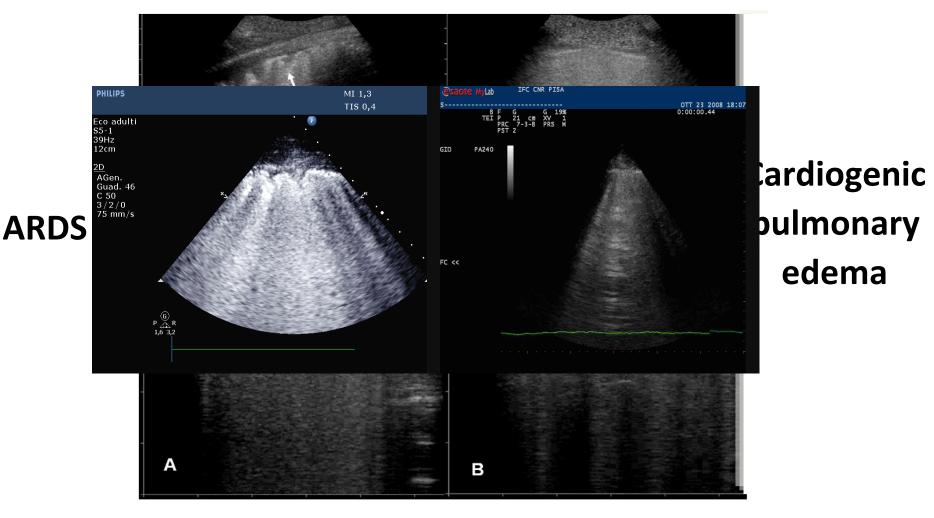
**ARDS** 



Copetti R, Soldati G, Copetti P. Cardiovasc Ultrasound. 2008;6:16

### **Cardiogenic edema vs ARDS**

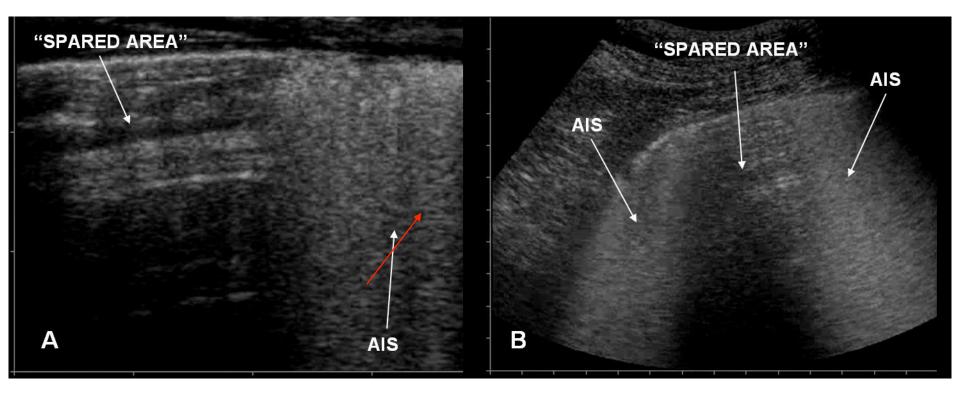
### SUB-PLEURAL ALTERATIONS



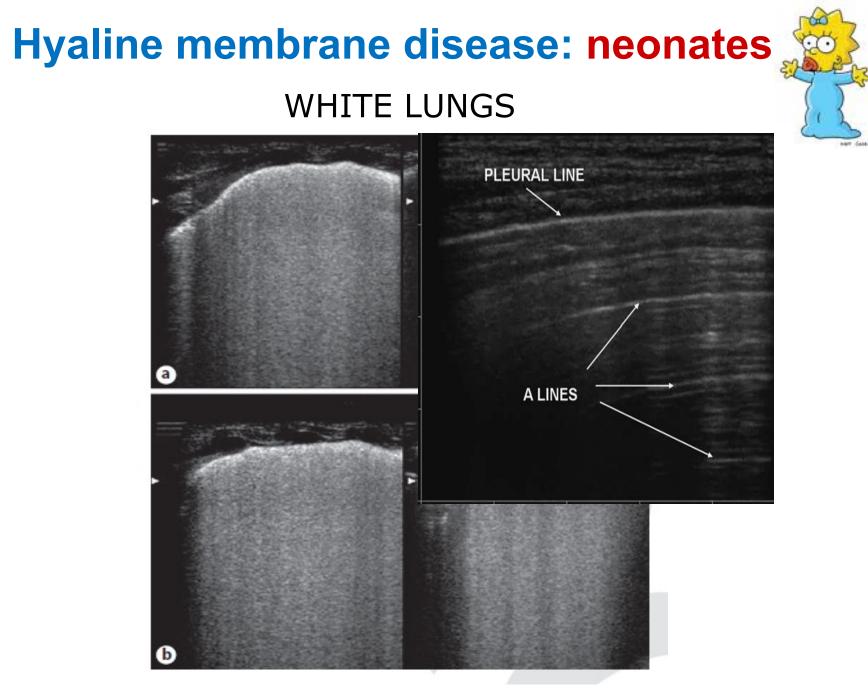
Copetti R, Soldati G, Copetti P. Cardiovasc Ultrasound. 2008;6:16



### SPARED AREAS

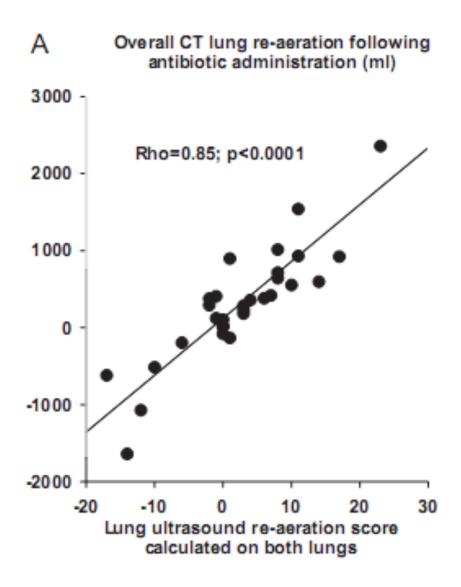


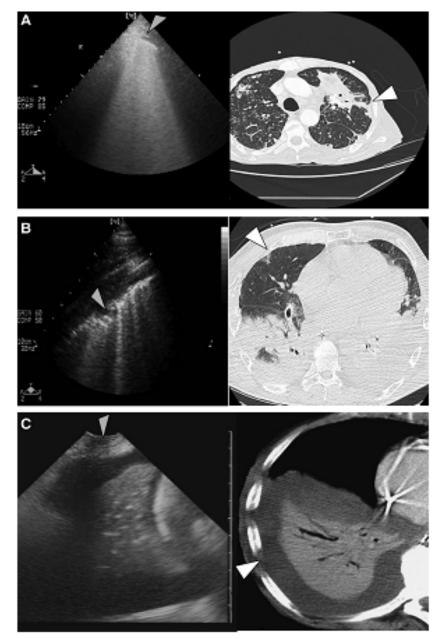
Copetti R, Soldati G, Copetti P. Cardiovasc Ultrasound. 2008;6:16



#### Copetti R et al. Neonatology 2007

### Recruitment





Bouhemad B et al. Crit Care Med. 2010

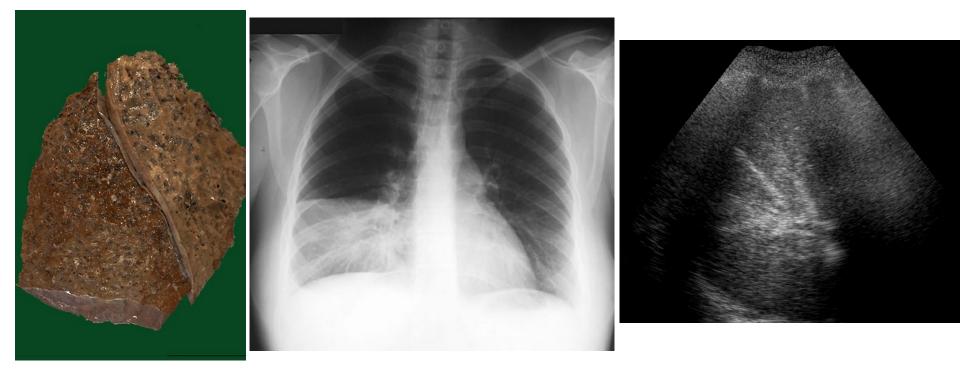
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### International Evidenced-based Recommendations for Point-of-Care Lung Ultrasound

Endorsed by the World Interactive Network Focused on Critical Ultrasound (WINFOCUS)

#### Writing Committee:

Giovanni Volpicelli (Chairperson)\*, Daniel Lichtenstein, Gebhard Mathis, Andrew Kirkpatrick, Luna Gargani, Vicki Noble, Gino Soldati, Roberto Copetti, Belaid Bouhemad, Angelika Reissig.

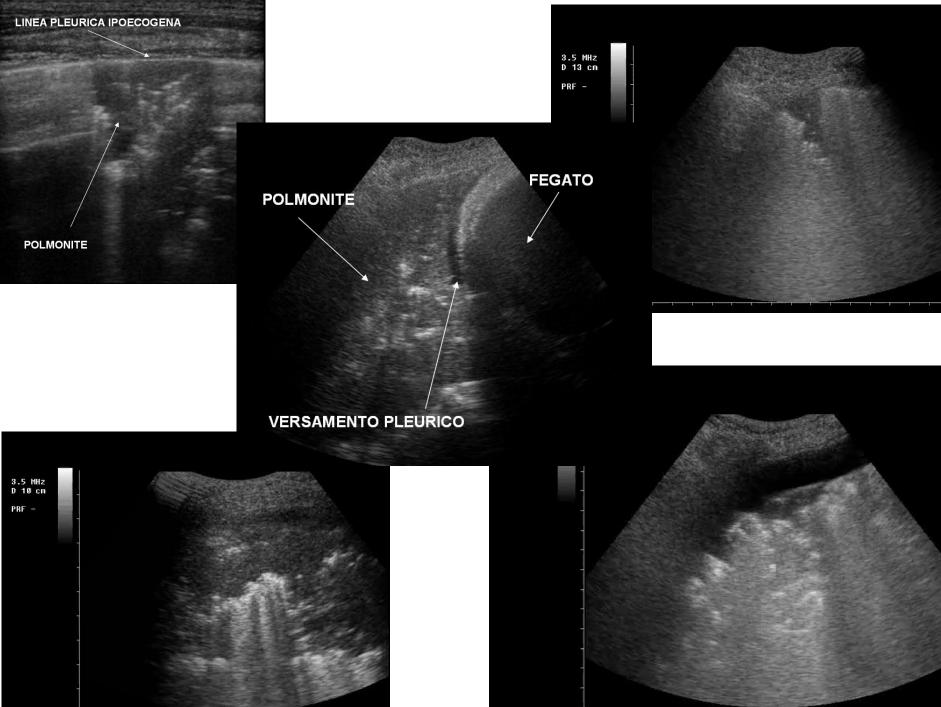
### Lung consolidation

Signs and clinical implications

B-D3-S1 (strong: level C) (this statement combines statements P-D3-S4 and P-D3-S5)

• The sonographic sign of lung consolidation is a subpleural echo-poor region or one with tissue-like echotexture.

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• In the evaluation of lung consolidation, the sonographic technique should commence with the examination of areas of interest (if present, e.g., area of pain) then progress to the entire lung, as needed.

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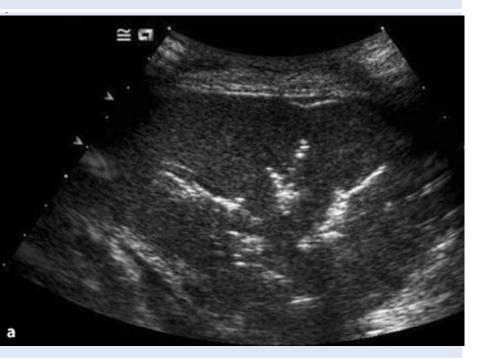


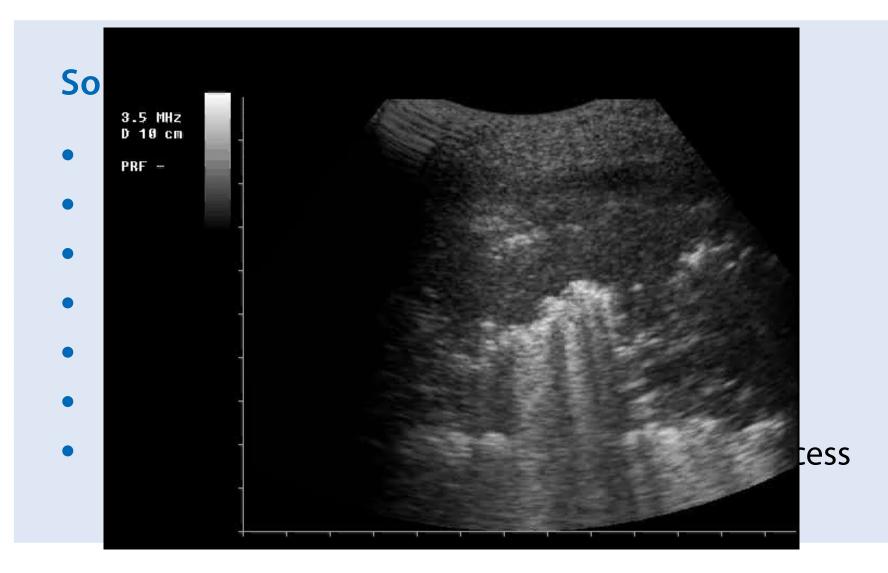
### Fluid bronchogram (point

- Blurred and serrated m
- Reverberation echoes
- Hypoechoic to anecho (microabscesses!)

### neumonia:

### he early stage







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NTENSIVE CARE MEDIC

• Lung ultrasound is a clinically useful tool to rule in pneumonia; however, lung ultrasound does not rule out consolidations that do not reach the pleura.

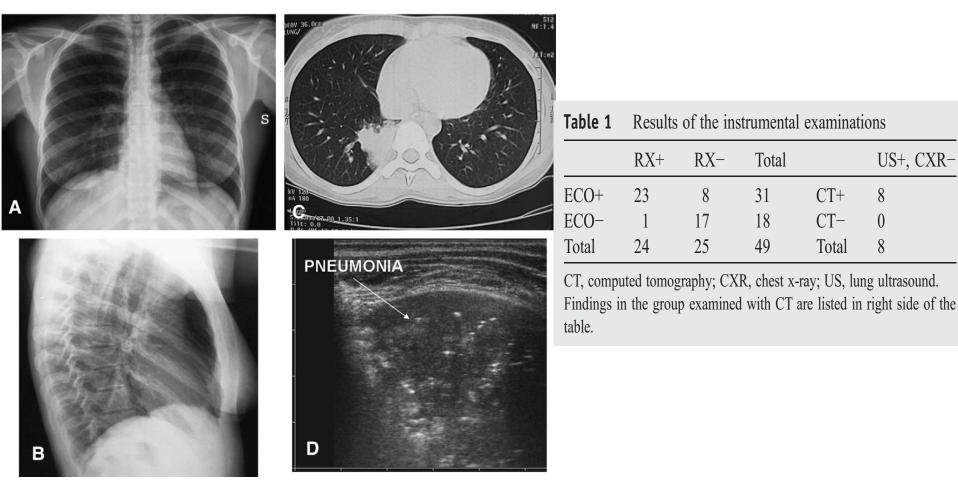
### B-D4-S8 (strong: level C)

• Lower-frequency ultrasound scanning may allow for better evaluation of the extent of a consolidation.

# Evaluation of lung ultrasound for the diagnosis of pneumonia in the ED

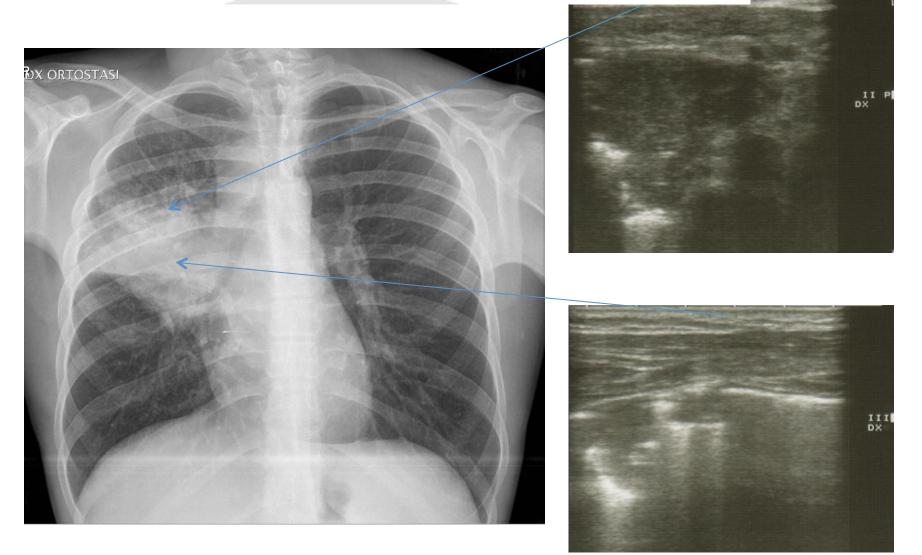
Stefano Parlamento MD<sup>a,\*</sup>, Roberto Copetti MD<sup>a</sup>, Stefano Di Bartolomeo MD<sup>b</sup>





#### Lung Ultrasound Characteristics of Community-Acquired Pneumonia in Hospitalized Children

Vito Antonio Caiulo,<sup>1</sup>\* Luna Gargani,<sup>2</sup> Silvana Caiulo,<sup>3</sup> Andrea Fisicaro,<sup>3</sup> Fulvio Moramarco,<sup>1</sup> Giuseppe Latini,<sup>4</sup> Eugenio Picano,<sup>2</sup> and Giuseppe Mele<sup>5</sup>



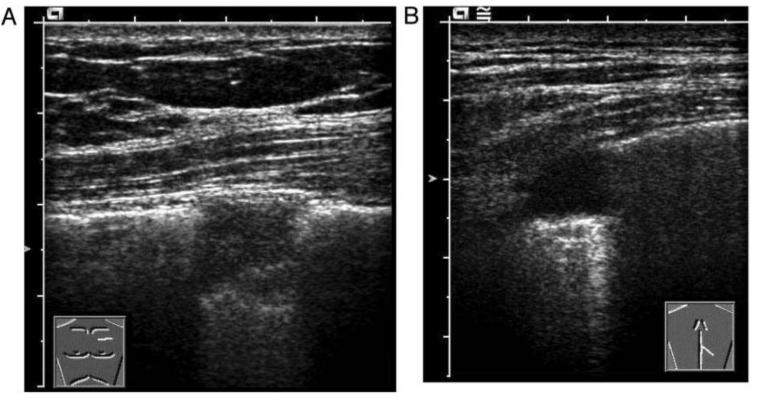
# **Pulmonary embolism**

# Thoracic Ultrasound for Diagnosing Pulmonary Embolism\*

### A Prospective Multicenter Study of 352 Patients

Gebhard Mathis, MD; Wolfgang Blank, MD; Angelika Reißig, MD; Peter Lechleitner, MD; Joachim Reuß, MD; Andreas Schuler, MD; and Sonja Beckh, MD

specificity 95%



Mathis G et al. Chest (2005)



or specialists in: ulmonology, Critical Care, Sleep Medicine, heracic Surgery, Cardierespiratory Interactions, nd related disciplines

### Accuracy of Point-of-Care Multiorgan Ultrasonography for the Diagnosis of Pulmonary Embolism

Peiman Nazerian, MD; Simone Vanni, MD, PhD; Giovanni Volpicelli, MD, FCCP; Chiara Gigli, MD; Maurizio Zanobetti, MD; Maurizio Bartolucci, MD; Antonio Ciavattone, MD; Alessandro Lamorte, MD; Andrea Veltri, MD; Andrea Fabbri, MD; Stefano Grifoni, MD

357 pts with suspected PE, final diagnosis in 30.8%

	Sensitivity (%)	Specificity (%)
Echocardiography	32.7	90.9
Lung ultrasound	60.9	95.9
Vein ultrasound	52.7	92.6
Multi-organ ultrasound	90	86.2

# **Clinical applications**

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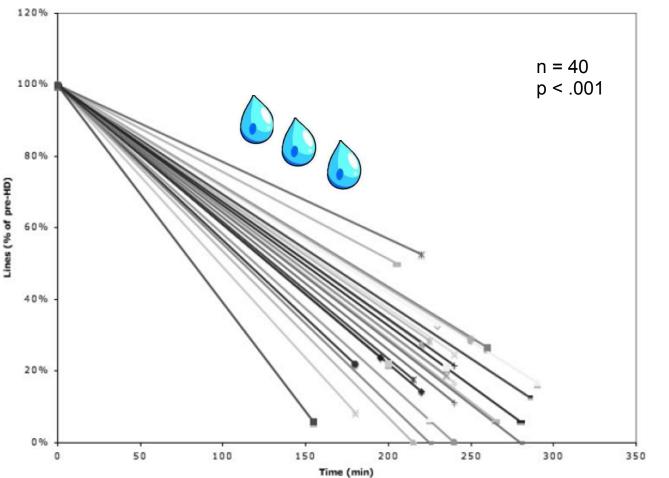
#### Ultrasound Assessment for Extravascular Lung Water in Patients Undergoing Hemodialysis\*

**Time Course for Resolution** 





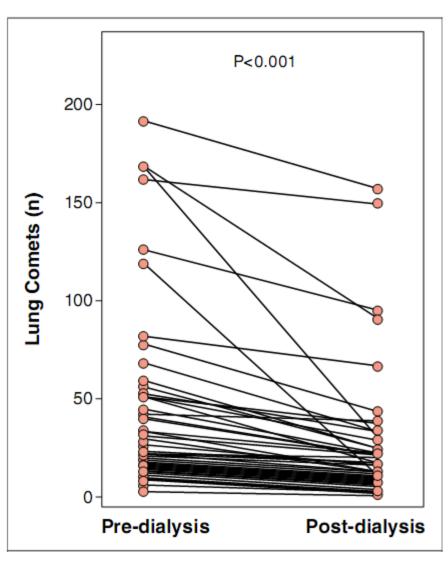
feasibility = 100% 10-15 mins



Noble VE et al. Chest 2009; 135:1433–1439.

#### Detection of Pulmonary Congestion by Chest Ultrasound in Dialysis Patients

Francesca Mallamaci, MD,\*† Francesco A. Benedetto, MD,‡ Rocco Tripepi,† Stefania Rastelli, MD,§ Pietro Castellino, MD PROF.,§ Giovanni Tripepi, STAT. DR.,† Eugenio Picano, MD PROF.,|| Carmine Zoccali, MD PROF.\*†



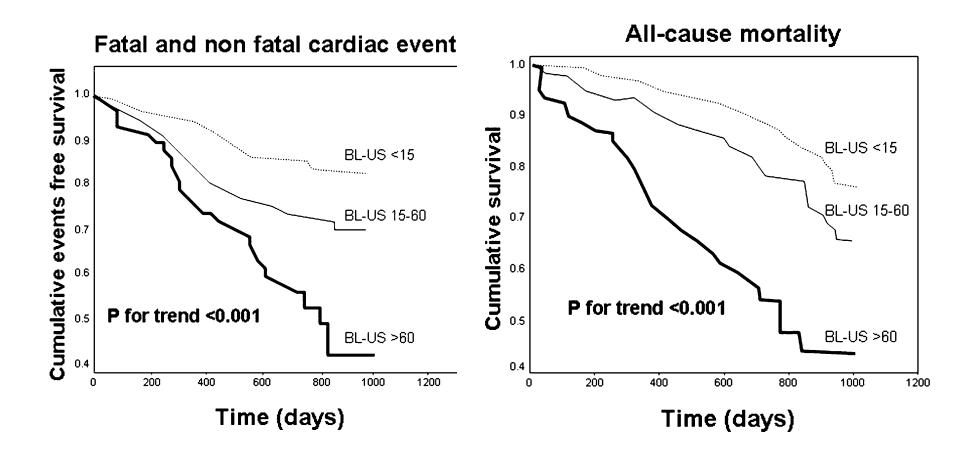


cardiac probe

- n = 75
- feasibility = 100%
- mean time needed = 4 mins (range 3-6)

Mallamaci F et al. JACC Cardiovascular Imaging 2010

## **Prognosis in dialysis**



Zoccali C et al. JASN 2013

## **Future directions**





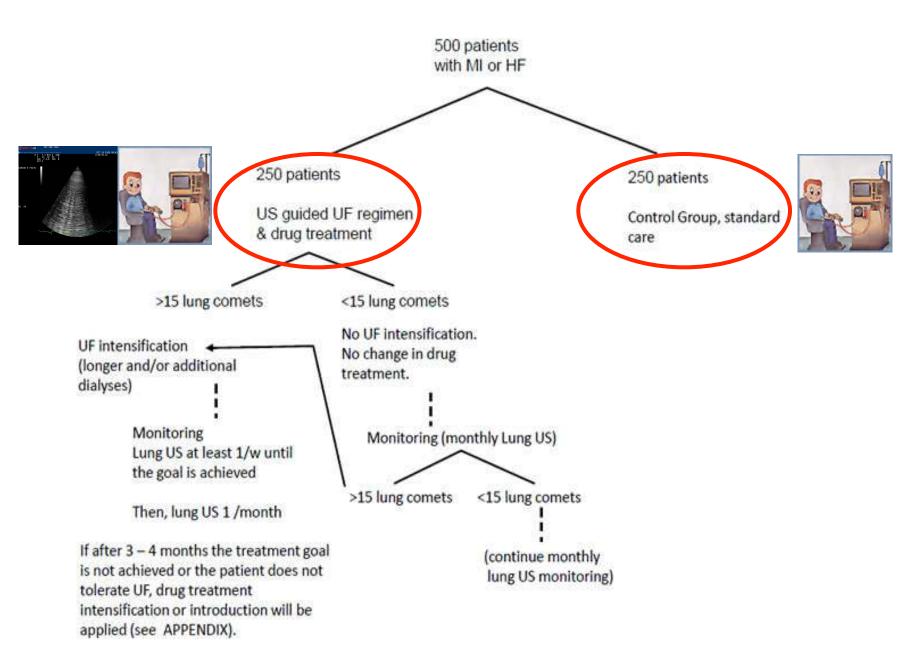
EUropean REnal and CArdiovascular Medicine Working Group

### Lung water by Ultra-Sound-guided Treatment to prevent death and cardiovascular complications in high risk end-stage renal disease patients with cardiomyopathy





## LUST



# **Clinical applications**

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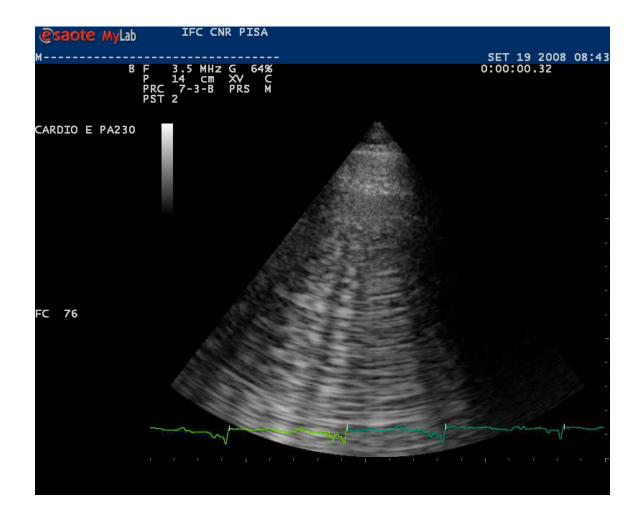
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## **B-lines: definition**

B-lines are the sonographic sign of the interstitial syndrome



#### Ist Consensus Conference on Pleural and Lung Ultrasound

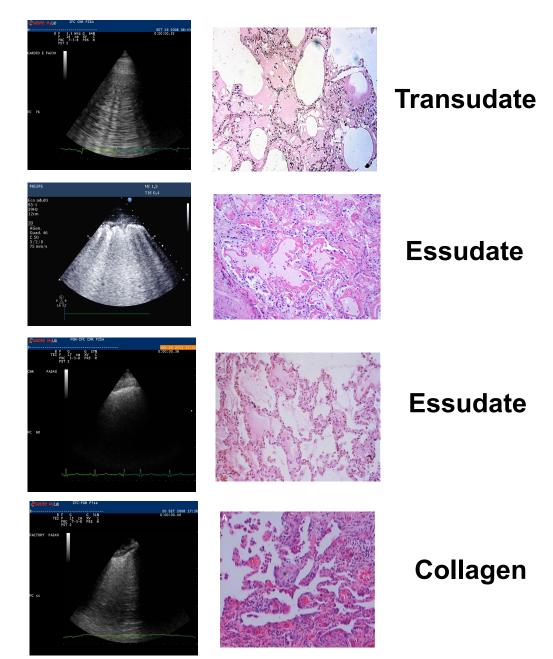
### **B-lines: a non-specific sign of interstitial syndrome**

Cardiogenic pulmonary oedema

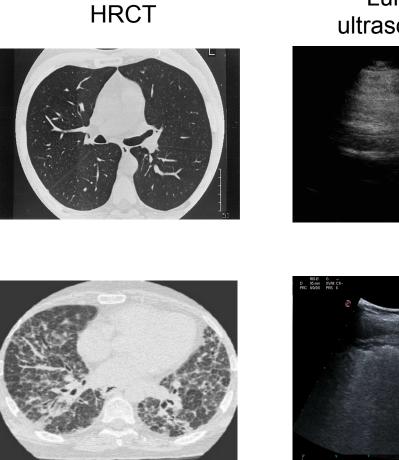
Non-cardiogenic pulmonary oedema

Interstitial pneumonia

Pulmonary fibrosis



### **Interstitial lung disease**



### Lung ultrasound

## Normal lung

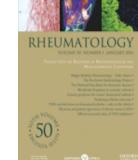


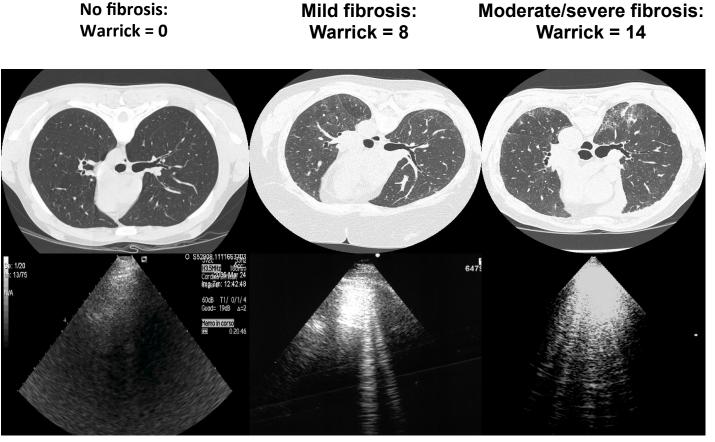
#### Pulmonary fibrosis

Lichtenstein D et al. Am J Respir Crit Care Med. 1997;156:1640 Volpicelli G. Am J Emerg Med. 2006;24:689-696



## **Correlation with chest CT**





**No B-lines** 

Mild B-lines

Moderate/severe B-lines

Gargani L, Bombardieri S, Picano E et al. Rheumatology 2009;48:1382-7

### LUS in systemic sclerosis



eular BMJIJournal

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Rheumatic

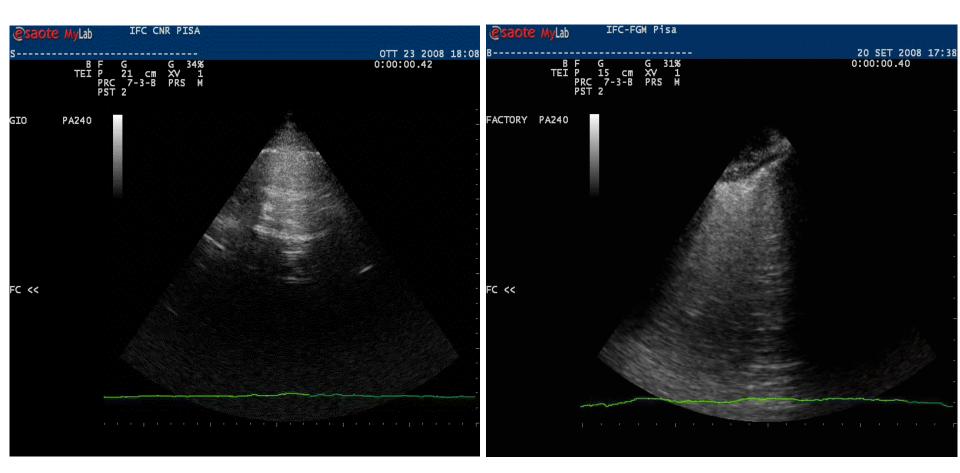
#### 58 SSc patients

		HRCT	
		Positive	Negative
LUS	Positive	36	10
	Negative	0	12

#### sensitivity 100%

Barskova T\*, Gargani L\*, Matucci Cerinic M et al. Ann Rheum Dis 2012

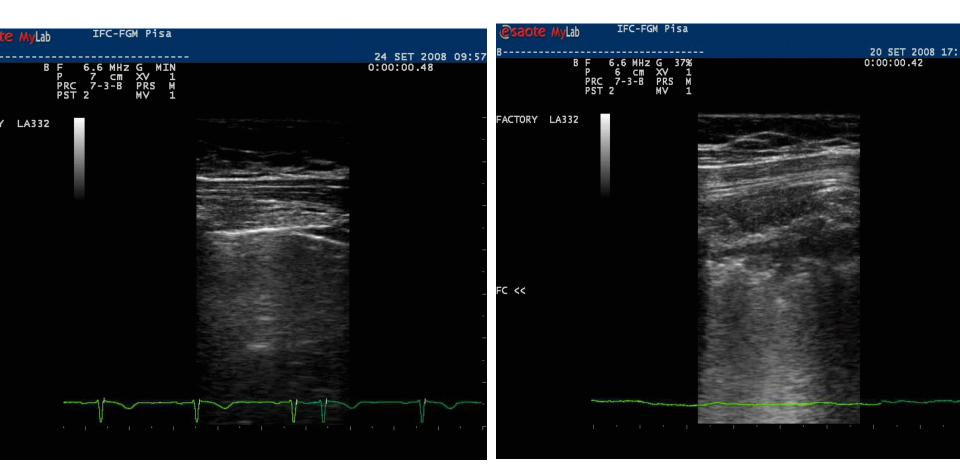
### Which probe?



#### Normal lung

BL, 61 year-old, SSc diffuse form

### Which probe?



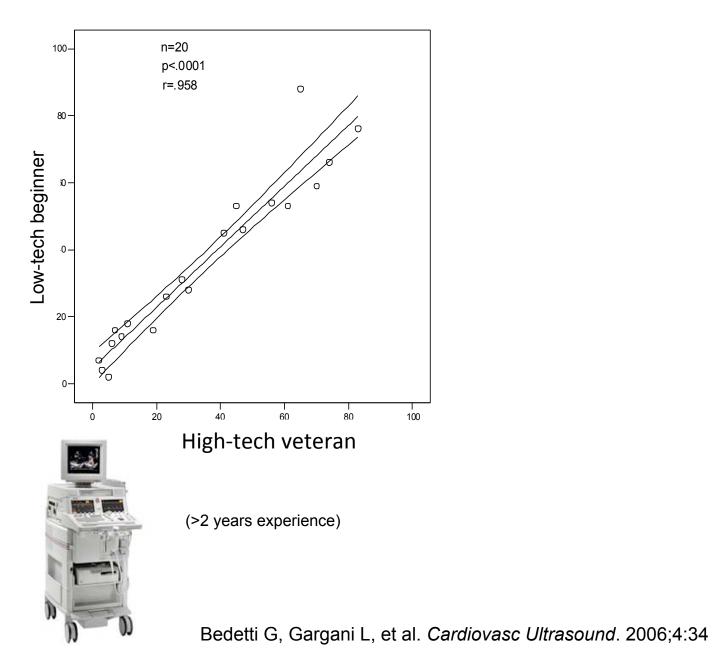
AR, 54 year-old, normal lung

BL, 61 year-old, SSc diffuse form

## Limitations

• Operator-dependance

## **Inter-observer variability**





(<1 hour experience)

## Limitations

Operator-dependance

Position

# **Position**

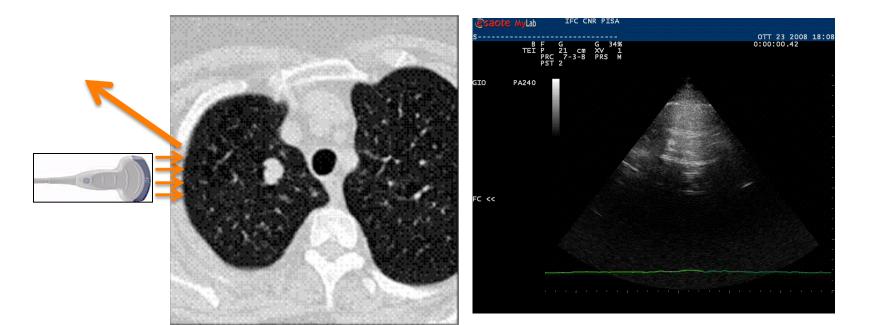
#### International Evidenced-based Recommendations for Point-of-Care Lung Ultrasound

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<Lung ultrasound does not rule out alterations that do not reach the pleura>



## Limitations

Operator-dependance

Position

• Specificity

## Watery or fibrotic B-lines?



#### Decompensated heart failure

Pulmonary fibrosis

### Lung ultrasound: a new tool for the cardiologist

				All Constants
	Acute cardiogenic pulmonary edema	Chronic heart failure	ALI/ARDS	Pulmonary fibrosis
Clinical setting	acute	chronic	acute	chronic
B-lines number	+++++	+/++/+++	+++++	+/++/+++
B-lines distribution	multiple, diffuse, bilateral (white lung)	multiple, diffuse, bilateral, following decubitant regions (black and white lung)	non-homogeneous distribution, presence of spared areas	more frequently posterior at lung basis
Other LUS signs	pleural effusion	pleural effusion	pleural effusion, pleural alterations, parenchymal consolidations of various size	pleural thickening
Echocardiogram	abnormal	abnormal	likely normal	likely normal

ALI = acute lung injury; ARDS = acute respiratory distress syndrome; LUS = lung ultrasound.



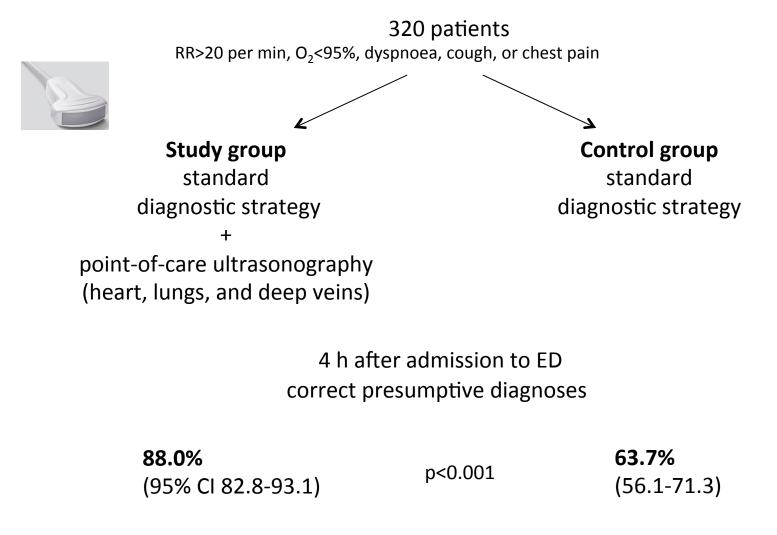
Table 2 The list of nine possible ultrasound patterns diagnosed in patients admitted for undifferentiated hypotension and the corresponding combination of findings detected at multiorgan point-of-care ultrasonographic evaluation

Ultrasound pattern	Organ evaluation	Corresponding signs
Hypovolemic	Heart	Hyperkinetic LV <sup>a</sup>
	Inferior vena cava	Diam. $<2 \text{ cm} + \text{Resp. collapse} >50 \%^{a}$
	Lungs	A pattern <sup>a</sup>
	Abdomen	Free fluids/Aortic aneurysm <sup>a</sup>
Distributive	Heart	Hyperkinetic LV
	Inferior vena cava	Diam. $<2 \text{ cm} + \text{Resp. collapse} >50 \%$
	Lungs	B pattern with consolidation or consolidation with air bronchograms <sup>b</sup>
Hypovolemic/distributive	Heart	Hyperkinetic LV <sup>a</sup>
• •	Inferior vena cava	Diam. $<2 \text{ cm} + \text{Resp. collapse} > 50 \%^{a}$
	Lungs	A/B pattern <sup>a</sup>
	Abdomen	Free fluids <sup>a</sup>
Obstructive cardiac tamponade	Heart	Pericard. effusion with tamponade
Obstructive pulmonary embolism	Heart	Dilated/Hypokinetic RV <sup>a</sup>
	Inferior vena cava	Sludge or no respiratory collapse and max. diam. >2 cm <sup>a</sup>
	Lungs	A pattern <sup>a</sup>
	Peripheral veins	Deep vein thrombosis <sup>a</sup>
Obstructive tension pneumothorax	Heart	Dilated/Hypokinetic RV
-	Inferior vena cava	Sludge or no respiratory collapse and max. diam. >2 cm
	Lungs	No sliding and pulse, no B-lines, no consolidation <sup>b</sup>
Cardiogenic	Heart	Hypokinetic left ventricle
C C	Lungs	B pattern <sup>b</sup>
Mixed	Pattern where criteria for more	1
	than a single diagnosis are satisfied (other than hypovolemic/distributive)	
Indefinite	Pattern where criteria for a single diagnosis are not satisfied or uncertain	

*LV* left ventricle, *RV* right ventricle <sup>a</sup> At least two of these signs <sup>b</sup> Necessarily present

# THE LANCET Respiratory Medicine

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Laursen CB, Sloth E et al. The Lancet Respiratory Medicine. 2014

## **Toward an integrated ultrasound approach Focused, point-of-care, whole-body ultrasound**

