

Lung Ultrasound in the Critically Ill

Ten signs: the alphabet for performing the BLUE-protocol

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Videos of lung ultrasound
can be consulted on

CEURF.net

(section BLUE-protocol)



The lung, unsuitable for ultrasound?

“The lungs are a major hindrance for the use of ultrasound at the thoracic level”.

In Harrison PR. Principles of Internal Medicine. 1992:1043

Intensive Care Med (1993) 19:353–355

Intensive Care
Medicine

© Springer-Verlag 1993

Intensive use of general ultrasound in the intensive care unit

Prospective study of 150 patients

Received: 1 July 1991; accepted: 3 December 1992

Announced in this article, sent in 1991 and defining critical ultrasound, i.e., a philosophy on a new use: one diagnosis, one immediate life-saving therapy. This concept includes the lung as a main target, and the physician (intensivist, ...) as a first-line user



Holistic ultrasound

One critical point to understand

CEURF has a personal point of view regarding critical ultrasound. This includes the choice of equipment. This is called *holistic ultrasound*.

CEURF defines a discipline as holistic when each of its parts (type of machine, type of probe, type of setting, type of priority, applications....) is connected to the others in such a way that it is mandatory to understand each of them for understanding that the whole can be, deeply, simplified for optimal efficiency.

The equipment is a critical step. It can transform critical ultrasound from a simple to a complicate field...



Just scan different

Which equipment for lung and whole body ultrasound in the critically ill?

This approach has been developed using simple machines



ADR-4000 (1982-1992) A 42-cm width, smaller than many nowadays laptops. Image resolution was sufficient for developing lung ultrasound. Some images from this system are featuring in the present document



Hitachi-405 (1992-2010) 30-cm width. Perfect on-site machine 10 years before the laptop advent

Why does CEURF teach a different point of view

Laptop machines, very popular in ERs and ICUs since the mid 2000s are good.

However, manufacturers of laptop machines have copy-pasted traditional radiological and cardiological cultures, not taking into account the *lung*. This has often resulted in poor access to lung ultrasound. The inclusion of this vital organ changes the vision of ultrasound into a holistic discipline. Doppler gets less mandatory (for respiratory and circulatory concerns). Filters can have destructive effects for lung ultrasound. The absence of cardiac windows is no longer a problem in most cases. The rules of critical ultrasound change from A to Z when lung ultrasound is considered.

Not only the lung but many areas are included in this vision (mainly venous assessment).



Why does CEURF teach a different point of view

The unit

Our unit is smaller than laptops. Not in height (of minor interest within a hospital) but in width, the only important dimension: 29 cm (33 cm with cart). Perfect for bedside use.

Our unit is faster: 7 seconds (the fastest start-on time).

Our unit is cleaner: flat keyboard, easy to clean.

Our unit is simpler. Few buttons, no Doppler, no harmonics etc: precisely the best for efficient lung ultrasound

Our unit has analogic image quality, i.e., a resolution image which the reader can see (and compare) in this document.

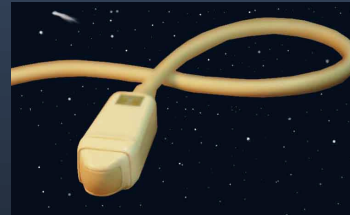
Our unit has a top. By definition, laptops have no top. On a top, probes etc. can be located, maybe increasing height, but mostly decreasing *width*.



Why does CEURF teach a different point of view

The probe

Our 5 MHz microconvex probe is perfect for lung imaging, because of its small footprint and its wide range: from 1 to 17 cm. It makes the best compromise for whole body assessment, with the advantage of imaging *lung, heart, veins, belly* (even optic nerve), of critical interest in acute settings (cardiac arrest, or routine)



Note: vascular probes are traditionally used for lungs and veins. Our universal probe can assess all veins (superficial like jugular, deep like IVC) in all sections (not restricted to one axis because of the probe dimension, which makes a limitation).

Note: Some microconvex probes found in the market have poor image resolution and/or poor depth (usually not more than 8-10 cm).

How to do anyway for those already equipped with traditional laptop machines

One can do critical (and lung) ultrasound with any type of equipment. It will just be more difficult (from slightly to highly). Up-to-date units can yield inferior results than ours, in terms of size, ergonomics, image resolution, rapidity, cost, mainly.

First get rid of all filters (provided they are not irreversibly fixed)

Then chose the probe, *time permitting*, an issue in the case of cardiac arrest: Vascular if thinking of pneumothorax as the cause of arrest, phased array if thinking of tamponade, abdominal if thinking for hemorrhage. Some cardiac probes are better than others. Our universal probe can be used successfully here as well as less urgent settings. Do not forget to carefully disinfect the probe for each change (a non-problem when using a unique probe).



The less worse compromise in ergonomics is obtained using ill-defined phased-array probes



The less worse compromise in image resolution is obtained using bulky abdominal probes

Note that since recently, some hand-held machines have all qualities than the ones we are accustomed since 1992

The ten basic signs

The bat sign



The A-line



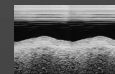
Lung sliding



The quad sign



The sinusoid sign



The tissue-like sign



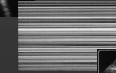
The shred sign



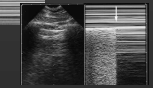
The B-line (& lung rockets)



The stratosphere sign



The lung point



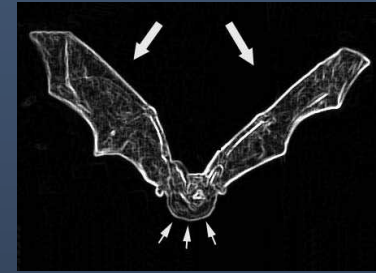
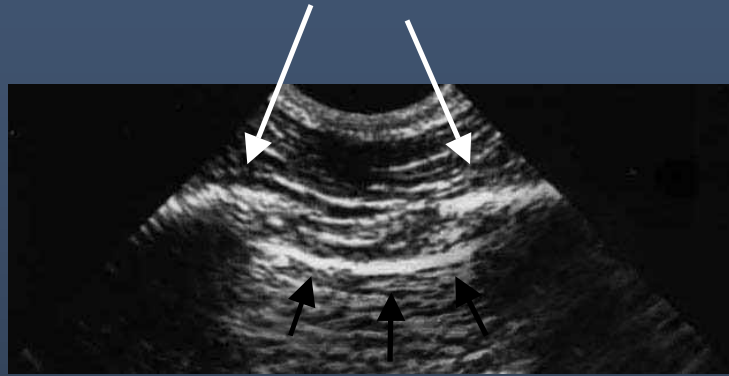
Important note

This is not a DVD. Dynamic images can be replaced by M-mode acquisition. Lung ultrasound is a standardized field, which can be understood perfectly by reading static images instead of mobile ones. DVD is a minor detail. For those who want videos anyway: go to www.CEURF.net (BLUE-protocol)

The mastery of these signs allows control of multiple settings: acute respiratory failure, ARDS management, hemodynamic therapy in shocked patient, neonates, traumatized patients. It works in up-to-date ICUs as well as austere areas or spaceships.

Two other signs (lung pulse, dynamic air bronchogram), are not dealt with here, for simplifying

1) The bat sign

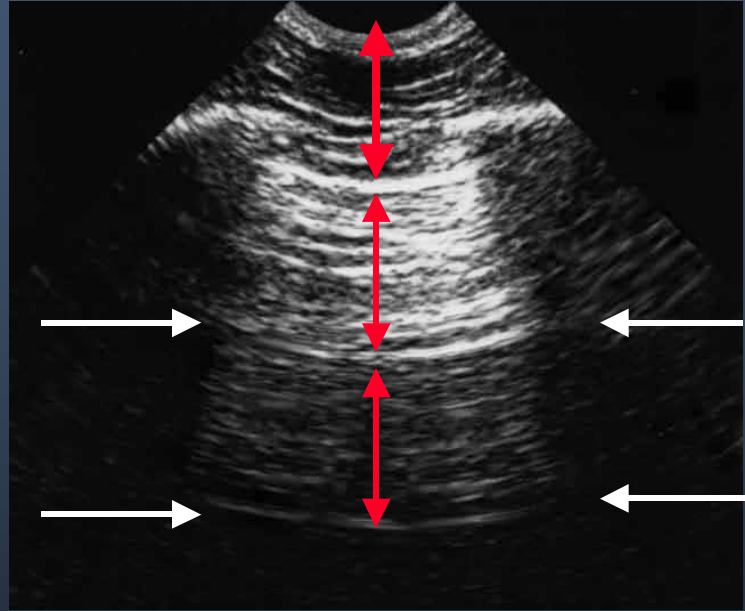


The bat sign

The pleural line and the upper and lower ribs make a permanent landmark

The bat sign, a basic step, allows to locate the lung surface in any circumstances (acute dyspnea, subcutaneous emphysema...)

2) The A-line

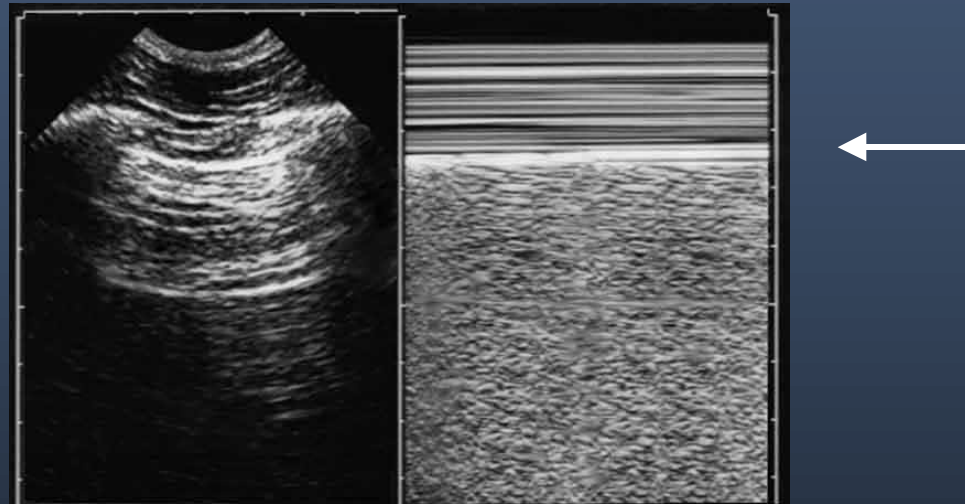


Hyperechoic equidistant horizontal artifacts arising from the pleural line

A-lines indicate air*, whether physiologic or pathologic

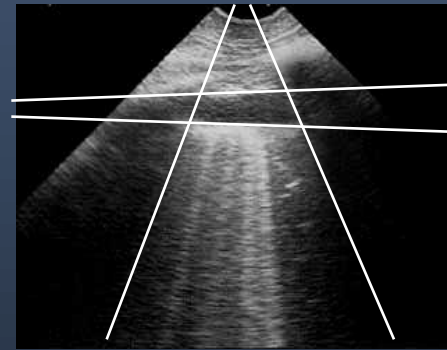
* For purists, the term *gas* is more appropriate

3) Lung sliding & seashore sign



The pleural line normally separates two distinct patterns (in M-mode).
This demonstrates lung sliding, without Doppler

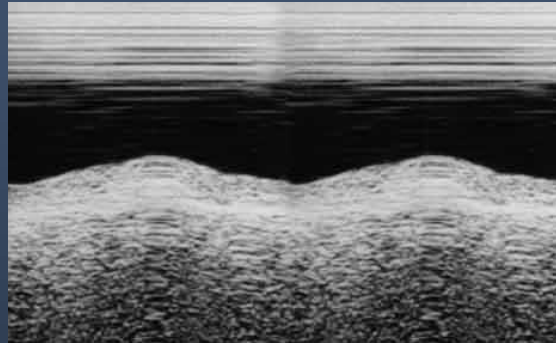
4) Pleural effusion: The quad sign



Quad image between pleural line, shadow of ribs,
and the lung line (deep border, always regular)

Quad sign and sinusoid sign are universal signs allowing to define any kind of pleural effusion regardless its echogenicity

5) Pleural effusion The sinusoid sign



Inspiratory movement of lung line toward pleural line

Sinusoid sign allows not only full confidence in the diagnosis of pleural effusion (associated with quad sign), but also indicates possibility of using *small* needle for withdrawing fluid

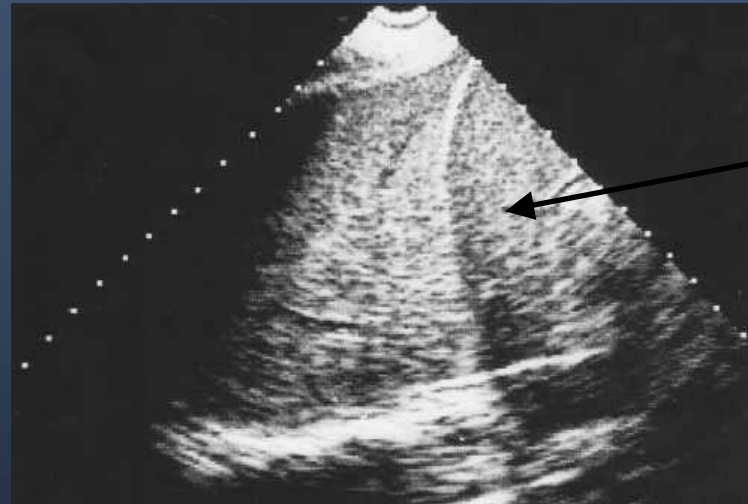
7) Lung consolidation (alveolar syndrome) Nontranslobar form: the shred sign



A shredded line, instead of the lung line: a specific sign

The shred (or fractal) line is the boundary between consolidated lung and aerated underlying lung. This line is quite always irregular, allowing immediate diagnosis

6) Lung consolidation (alveolar syndrome) Translobar form: the tissue-like sign



spleen
or liver

A fluid disorder looking like a solid organ

When the consolidation is huge
(and fills the whole lobe), no fractal
sign can be generated



An example of PLAPS, associating lung
consolidation and pleural effusion (see at
BLUE-protocol section)

8) B-lines, lung rockets & interstitial syndrome



Lung rockets
(1992's technology)

The B-line is*

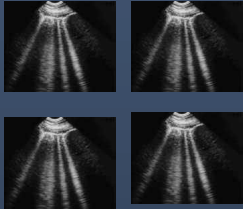
- 1- a comet-tail artifact (100% of cases)
- 2 - arising from the pleural line (100%)
- 3 - moves with lung sliding (100%)
- 4 - hyperechoic (97%)
- 5 - long without fading (96%)
- 6 - erases A lines (94%)
- 7 - well-defined - laser-ray like (93%)

Using these 7 features, the B-line is distinct from all other comet-tail artifacts

* Since 2012, we have updated the definition of the B-line by introducing the frequencies into brackets

8) B-lines, lung rockets & interstitial syndrome

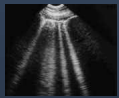
Important semantic notes



Diffuse lung rockets

Lung rockets at the four points of anterior chest wall

They define pulmonary edema (hemodynamic or inflammatory - see BLUE-protocol) mainly



Lung rockets

Three (or more) B-lines between two ribs

They define interstitial syndrome (can be focal)



B-lines

A certain type of comet-tail artifact (see definition previous slide)

Defines mingling of air and fluid abutting pleura. Can be isolated and mean simple fissura



Comet-tail artifact

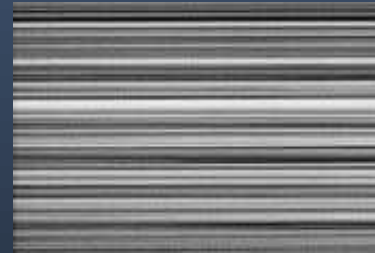
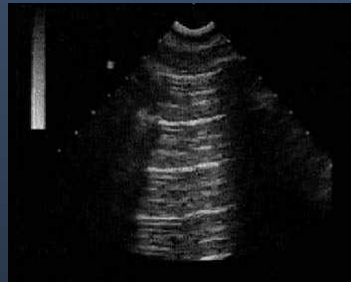
Vertical artifact, visible at the lung surface or elsewhere, can be due to multiples causes (gas, metallic materials), called E-lines, Z-lines (see left), K—lines, S-lines, W-lines....). Includes the B-line among others

9) Pneumothorax Three signs - Signs 1 & 2



- 1) Abolished lung sliding
Yielding stratosphere sign on M-mode

1982
technology!



- 2) The A-line sign: already in the scale (see A-line slide)

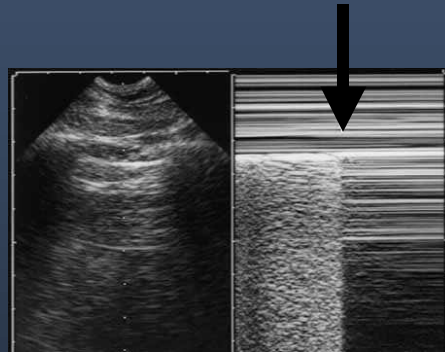
One B-line is enough for ruling out the diagnosis, confidently, where probe is applied

Abolished lung sliding with the A-line sign at anterior chest wall is called the "A'-profile". It allows immediate *suspicion* of all cases of pneumothorax

10) Pneumothorax

Three signs - Sign 3: lung point

Lung point: specific to pneumothorax, therefore mandatory for accurate and safe use in the critically ill



Sudden, on-off visualization of a lung pattern (lung sliding and/or B-lines) at a precise area where the collapsed expiratory lung slightly increases its surface of contact on inspiration. This assumes that the A'-profile was previously detected (see below, BLUE-protocol).

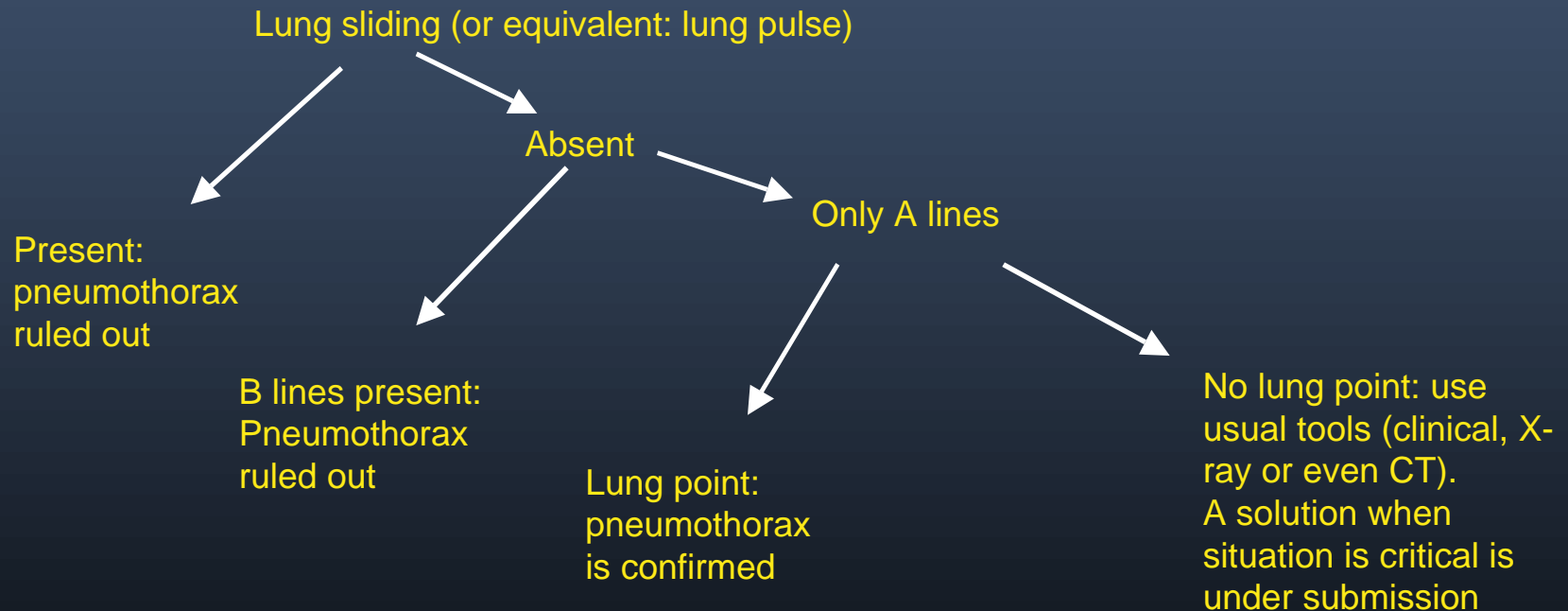
Lung point indicates volume of pneumothorax

The lung point also shows that signs (especially abolished lung sliding) are not due to technical inadequacies of machine (beware modern machines not designed for lung)

Pneumothorax

The diagnosis of *air within air*

A basic decision tree



Value of the signs used

Sensitivity (%)
Specificity (%)

Source
(CT as gold standard)

Pleural effusion

97 - 94

Intensive Care Med (1999) 25: 955-958
© Springer-Verlag 1999

ORIGINAL

Feasibility and safety of ultrasound-aided thoracentesis in mechanically ventilated patients

Alveolar consolidation

90 - 98

Intensive Care Med (2004) 30:276-281
DOI 10.1007/s00134-003-2075-6

ORIGINAL

Ultrasound diagnosis of alveolar consolidation in the critically ill

Interstitial syndrome

100 - 100*

AM J RESPIR CRIT CARE MED 1997;156:1640-1646.

The Comet-Tail Artifact
An Ultrasound Sign of Alveolar-Interstitial Syndrome

Complete pneumothorax

100 - 91



Chest (1995) 108:1345-1348

A Bedside Ultrasound Sign Ruling Out Pneumothorax in the Critically Ill: Lung Sliding

Occult pneumothorax

79 - 100

Intensive Care Med (1999) 25: 383-388
© Springer-Verlag 1999

ORIGINAL

The comet-tail artifact: an ultrasound sign ruling out pneumothorax

Intensive Care Med (2000) 26: 1434-1440
DOI 10.1007/s001340000627

ORIGINAL

The "lung point": an ultrasound sign specific to pneumothorax

* 93/93 in Abstract when compared with radiograph, 100/100 in Results when compared with CT

Crit Care Med 2005 Vol. 33, No. 6

Clinical Investigations

Ultrasound diagnosis of occult pneumothorax*

Some semantic details

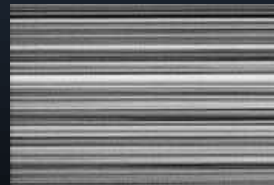
Literature can enrich, but sometimes confuse. Please note:

Lung comets are not lung rockets. The physiopathologic meaning of these two labels is fully different

The term *comet-tail artifact* is not representative for interstitial syndrome

The term "*alveolar-interstitial syndrome*" is radiological, but inappropriate for ultrasound, which detects either interstitial syndrome (lung rockets) or alveolar syndrome (shred sign), fully distinctly.

The term *barcode sign* is sometimes used instead of stratosfere sign, but we suggest to be cautious for avoiding deadly confusions generated by the new barcodes



Maybe our main message: the *neonate*



The whole of these ten signs (also signs not described here, dynamic air bronchogram and lung pulse) are found again *with no difference* in the critically ill neonate.

These signs have been carefully assessed in the adult, using irradiating tool: CT. We do not intent to publish data in neonates (meaning CT use*, of poor interest for the involved neonate). We just invite pediatricians working in neonate ICUs, when they will see a quad sign (shred sign, lung point, etc) in a neonate with normal or ill-defined bedside radiograph, to consider that ultrasound describes the true disorder.

Pediatric Crit Care Med 2009;10:693-698

Review Article

Ultrasound examination of the lungs in the intensive care unit

* We currently compile all cases where CT has been already ordered and performed, however. The present review article describes our observations in neonates



Respiratory applications of lung ultrasound

Anesthesiology 100:9-15

NEJOM 357:2277-2284
(Brenner)

Intensive Care Med
25:955-958

Crit Care Med 33:1231-
1238

**I - Avoid Referral
to CT**

**II - Limit Bedside
Radiographies**

**III - Decrease Radiation
Doses**

IV - Safe Thoracentesis

V - Pneumothorax

**VI - Pulmonary
Edema vs
COPD**

**VII - Pulmonary
Embolism**

VIII - Trauma

IX - Cardiac Arrest

X - Acute Dyspnea

Intensive Care Med
24:1331-1334

Chest 123:2154

Chest 130:533-538
(F. Silva)

Chest 134:117-125

Circulatory application of lung ultrasound



Chest 2009;136:1014-1020

A-lines & B-lines: lung ultrasound as a bedside tool
for predicting PAOP in the critically ill

Lung ultrasound, clinical applications...

Countless applications are accessible - nature and volume of pleural effusion - pulmonary abscess - distinction between thickened interlobular septa and ground-glass areas - lung contusion - overdistension - alveolar recruitment - immediate diagnosis of atelectasis when still aerated - distinction between hemodynamic and permeability-induced pulmonary edema - phrenic function - ultrasound-assisted thoracentesis, in mechanically ventilated patients - ETC

Recently published:

(Chest 2008) : the BLUE-protocol, a simple approach allowing diagnosis of acute respiratory failure

(Chest 2009) : FALLS-protocol. Lung ultrasound as a method for controlling fluid therapy in the shocked patient

(PCCM 2009) : Lung ultrasound in the critically ill neonate

(Chest 2009) : Distinction atelectasis versus pneumonia using the dynamic air bronchogram

(Critical Ultrasound Journal 2011) : the BLUE-points, standardized areas of investigation used in the BLUE-protocol

(Expert Rev Respir Med 2012) : the FALLS-protocol



The BLUE-protocol

Main principle : An ultrasound analysis of lungs (and veins in suitable cases) allows to define seven characteristic profiles representative of the 5 most frequent causes of acute respiratory failure (seen in 97% of patients). The BLUE-protocol accuracy (90.5%) is enhanced once integrated in the history, physical examination, basic tests (EKG, venous blood tests), and simple echocardiography.

The first aim of the BLUE-protocol is, by providing an immediate diagnosis, therefore a quicker relief in a dyspneic patient.

The second aim is to decrease the need for tests: heavy (CT, sophisticated echocardiography), painful (arterial blood analysis), irradiating, in particular cases (pregnancy), as well as improving care level in scarce resource areas.



Chest 2008; 134:117-125

Relevance of Lung Ultrasound in the Diagnosis of Acute Respiratory Failure - the BLUE-protocol



The BLUE-protocol, just one example: Fast diagnosis of pulmonary edema

After history and physical examination, the probe is inserted on two standardized points of the anterior chest wall (i.e., four for both lungs).

In acute hemodynamic pulmonary edema with respiratory failure, the anterior pattern observed in 97% of cases is diffuse lung rockets associated with lung sliding. This pattern, called the B-profile, is obtained in 20 seconds.

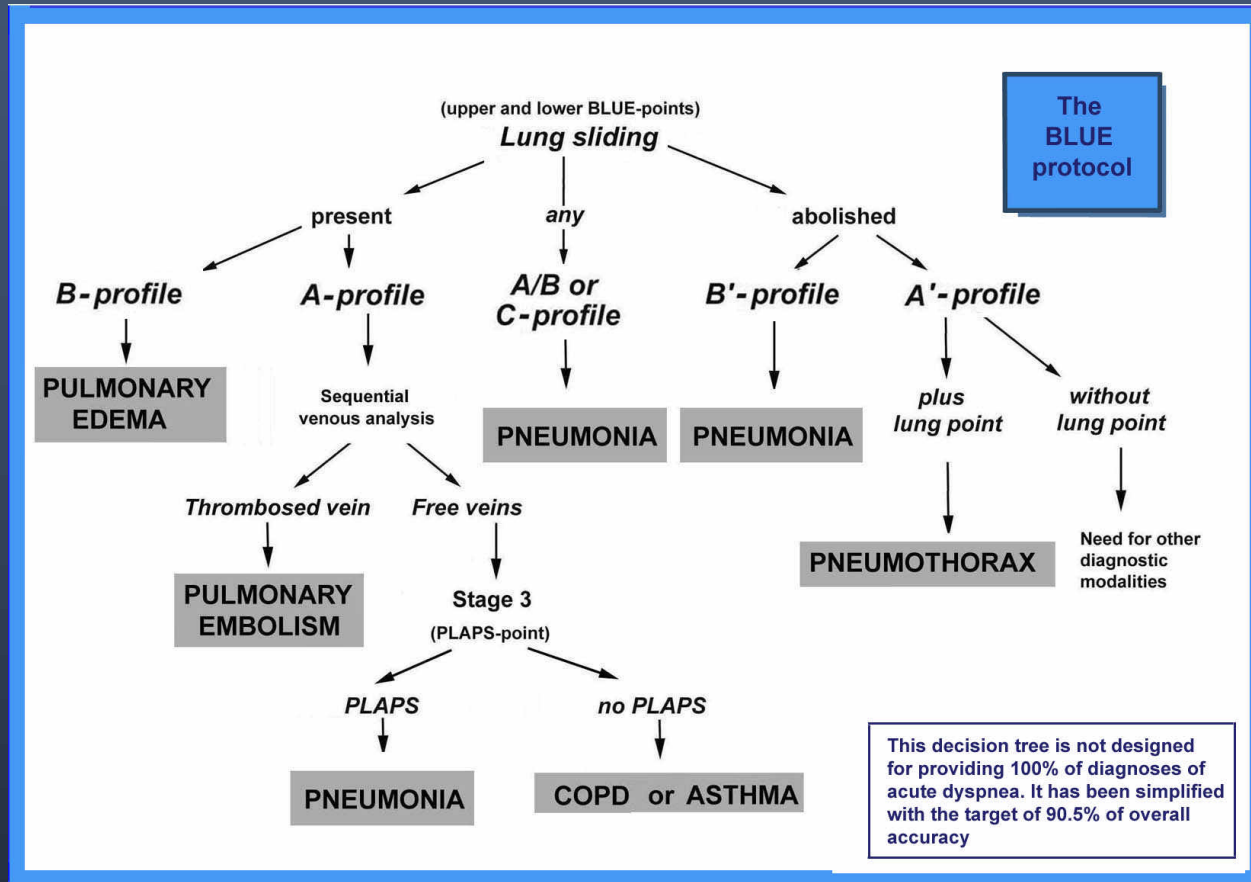
Specificity is 95%. False-negatives are usually cases of acute interstitial pneumonia with still conserved lung sliding.

Chronic interstitial diseases are not included since BLUE-protocol included the 97% of patients having the 5 most frequent groups of diseases: pneumonia - pulmonary edema - COPD and asthma - pulmonary embolism - pneumothorax. (Countless diseases make the 3% of remaining cases).

Notes: facing a B-profile, the BLUE-protocol is concluded. Posterior lung and venous analysis can be done at will by the physician. They usually provide redundant information (show free veins etc), but can on occasion have some relevance. The aim of the BLUE-protocol is to provide basic piece of information with maximal simplicity. E.g., for diagnosing anyway chronic lung disease, the history is usually a major element. Facing a first episode, some elements from lung ultrasound and, of prime importance, simple cardiac sonography will immediately alert the physician - normal left heart contractility, enlarged right heart, and others. Reminder: this is a rare cause.



The BLUE-protocol decision tree



Video-clips of the *BLUE*-profiles can be seen on www.ceurf.net

BLUE-protocol and PLAPS

The BLUE-protocol associates signs with signs, and signs with locations. The detection of an image combining pleural effusion and/or lung consolidation at a posterior area (supine patient) has basic relevance. The practical term *PLAPS* (postero-lateral alveolar and/or pleural syndrome) indicates that the image can be pleural, or alveolar, or both. Even though PLAPS is uni- or bilateral, minute (see image) or substantial, it is integrated in the decision tree of the BLUE-protocol: in acute respiratory failure, with an A-profile (anterior normal lung surface) and a free venous network, a PLAPS indicates pneumonia with high accuracy.

The concept of PLAPS allows to bring 10 signs (including quad sign, sinusoid sign, fractal sign & tissue-like sign) to 7 signs.



This PLAPS, seen at the PLAPS-point, associates here minute pleural effusion and minute consolidation of the end of lower lobe. Note if the image is too ill-defined for distinguishing effusion from consolidation, this does not change the concept: it is a PLAPS.

The BLUE-protocol is one application of holistic ultrasound

One critical example

Venous ultrasound is central to the BLUE-protocol. It is mandated each time there is an A-profile (normal anterior lung pattern).

It does not require vascular probes. Our microconvex probe assesses all veins (femoral, caval...) in all incidences (long axis, short axis).

It carefully focuses on calf veins, which are usually neglected, but are of high accessibility using our probe and adapted approach. Isolated calf deep venous thrombosis (DVT) is a frequent finding in massive pulmonary embolism.

Once a DVT is detected, the association of “A-profile plus DVT” provides diagnosis of massive pulmonary embolism with 81% sensitivity & 99% specificity.

This immediately reduces the needs for sophisticated Doppler echocardiographic approach. A simple visualization of the dilated right chambers using our microconvex probe can be performed at this step.

In extreme emergencies (cardiac arrest etc), the same probe will cover all areas of interest.

One probe, one simple cost-saving machine, the adjunction of the lung, the definition of a simple emergency cardiac sonography...

This is holistic ultrasound.



FALLS-protocol

The main derived product of the BLUE-protocol. Allows to define which patient in acute circulatory failure should receive fluid therapy, and when to discontinue it. Can be used even in absence of suitable cardiac window. Provides in addition a direct parameter of clinical volemia

Special Report

EXPERT
REVIEWS

Fluid administration limited by lung sonography: the place of lung ultrasound in assessment of acute circulatory failure (the FALLS-protocol)

Expert Rev. Respir. Med. 6(2), 155–162 (2012)

Daniel Lichtenstein

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dlicht@free.fr

The FALLS-protocol is included in a limited investigation to diagnose the cause of shock. After simple echocardiography has ruled out obstructive shock (tamponade, pulmonary embolism, pneumothorax), the lung is investigated. Absence of disseminated lung rockets rules out cardiogenic shock. At this point, hypovolemic and septic shock are differential diagnoses (rarities apart), and the FALLS-protocol provides fluid therapy with constant monitoring of lung artifacts. Hypovolemic shock will eventually improve – septic shock will not, and the slight excess fluid creates an early, silent stage of interstitial edema, demonstrated by B-lines, demanding interruption of fluid therapy. This sequential approach, combined with the usual, clinical, biochemical and echocardiographic parameters, must be evaluated in multicenter studies.

KEYWORDS: acute circulatory failure • fluid responsiveness • hemodynamic assessment • lung ultrasound

FALLS-protocol

Its principle at a glance

For assessing the cause of a circulatory failure with no orientation, FALLS-protocol uses Weil's classification.

A first look to the pericardium, then right ventricle size (coupled with search of DVT), then lung sliding rules out rapidly tamponade, embolism, pneumothorax, i.e., schematically, obstructive shock.

A search for a B-profile rules out (if negative) a cardiogenic shock of left origin, i.e., the huge majority.

Patients at this step are labelled "FALLS-responders" (they have usually the A-profile or FALLS-equivalents: A/B profile, C profile...). They receive fluid therapy. Those who respond (clinical, biological evolution) have hypovolemic shock.

If fluid therapy does not improve clinical signs of shock, it is continued and will eventually generate an interstitial syndrome, which is immediately recognized, at an early, infra-clinical state. The change from A to B-lines is called the FALLS-endpoint. Such situation defines, by default, distributive shock, i.e. in daily practice, septic shock.

(More can be consulted in: CEURF.net. Expert Rev Respir Med 6:155-162. Whole body ultrasonography in the critically ill, Chap 23, Springer 2010, hSR Proceedings in Critical Care, in press)



Clearance for fluid therapy



Endpoint for fluid therapy

SESAME-protocol

Practical contraction of SESAMOOSIC, “Sequential Emergency Sonography Assessing Mechanism Or Origin of Shock of Indistinct Cause”

Indication : extreme circulatory failure, cardiac arrest

First peculiarity: SESAME begins at lung. Main reason: lung is always feasible (unlike heart), two seconds per lung are sufficient. Two critical data are provided: no tension pneumothorax, clearance for immediate fluid therapy.

Cardiac sonography immediately follows. If no cardiac window is available, the BLUE-protocol is used for diagnosing pulmonary embolism (specificity 99%). Cardiac arrest due to extreme hypovolemia is likely when huge amounts of fluid are detected (pleura, peritoneum, soft tissues...).

Note : SESAME-protocol highlights the principle of holistic ultrasound. Our machine switches on in 7 secondes. No choice of probe has to be done, no setting. The same probe is applied at lung surface, heart, vessels, abdomen... without any adaptation. Even without gel*

* Echolite®: a coupling agent with the critical advantage (apart from vanishing spontaneously after 2 minutes) of an extremely fast protocol, less than two seconds is necessary from one area to another, remote area (lungs/calf e.g.). Avoids slippery thorax, a hindrance for treating cardiac arrest. Soon available.

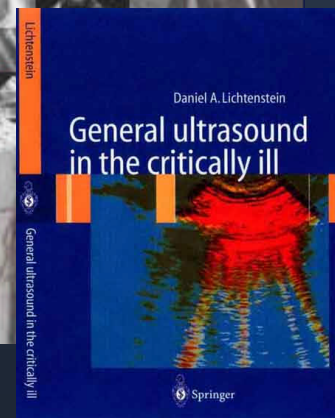
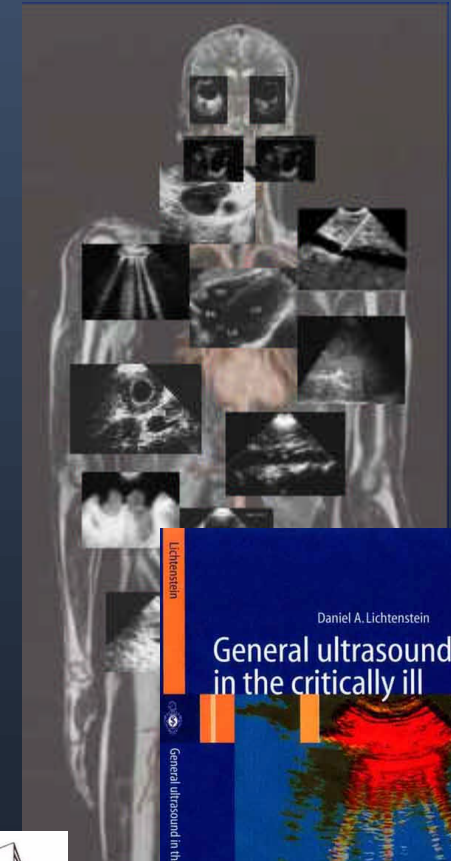


Lung ultrasound is a small part of critical ultrasound

The field of critical ultrasound, defined in our 1992 edition, used a 1982 technology.

This edition did not make use of acronyms and simply described search for free blood, simple cardiac sonography (known usually under the name of FAST or FATE/FEER protocols), inferior caval vein, optic nerve, subclavian vein cannulation...

The SLAM, subsequently created (Section of the Limitation of Acronyms in Medicine), accepts acronyms provided they first describe original research, second do not create confusion in daily talks. SLAM also does not advise the use of US (confusing) and LUS (for esthetical purpose), suggesting to write “lung ultrasound” in whole letters.



One positive side effect of the laptop tech'

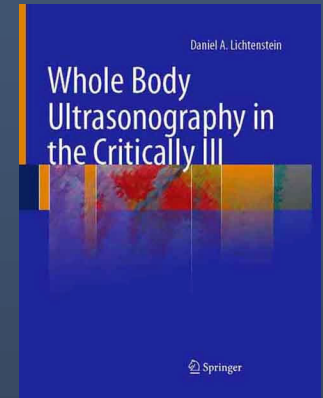
The recent burst of laptop technology (years 2002 and more) had anyway a positive outcome, in spite of the large width of these units: making know ultrasound to emergency physicians. Countless papers have been published, all confirming the value of lung ultrasound in the critically ill. Here are quoted some main authors, apologizing for possibly missing works since it is impossible to quite all:

- Balik M, Plasil P, Waldauf P, Pazout J, Fric M, Otahal M & Pacht J. Ultrasound estimation of volume of pleural fluid in mechanically ventilated patients. *Intensive Care Med* 2006;318-321
- Blaivas M, Lyon M, Duggal S. A prospective comparison of supine chest radiography and bedside ultrasound for the diagnosis of traumatic pneumothorax. *Acad Emerg Med* 2005 Sep;12(9):844-9
- Bouhemad B, Zhang M, Lu Q, Rouby JJ. Clinical review : bedside lung ultrasound in critical care practice. *Crit Care* 2007;11:205
- Copetti R, Cattarossi L. Ultrasound diagnosis of pneumonia in children. *Radiol Med (Torino)*. 2008 Mar 113(2):190-198. Epub 2008 Apr 2
- Dulchavsky SA, Hamilton DR, Diebel LN, Sargsyan AE, Billica RD, Williams DR. Thoracic ultrasound diagnosis of pneumothorax. *J Trauma* 1999 47:970-971
- Fagenholz PJ, Gutman JA, Murray AF, Noble VE, Thomas SH, Harris NS. Chest ultrasonography for the diagnosis and monitoring of high-altitude pulmonary edema. *Chest* 2007 131:1013-1018
- Gargani L, Lionetti V, Di Cristofano C, et al. Early detection of acute lung injury uncoupled to hypoxemia in pigs using ultrasound lung comets. *Crit Care Med* 2007; 35: 2769-2774
- Lerolle N, Guérot E, Dimassi S, Zegdi R, Faisy C, Fagon JY, Diehl JL. Ultrasonographic diagnosis criterion for severe diaphragmatic dysfunction after cardiac surgery. *Chest* 2009;135:401-407
- Mathis G, Blank W, Reißig A, Lechleitner P, Reuß J, Schuler A, Beckh S (2005) Thoracic ultrasound for diagnosing pulmonary embolism. A prospective multicenter study of 352 patients. *Chest* 128:1531-1538
- Maury E, Guglielminotti J, Alzieu M, Guidet B & Offenstadt G. Ultrasonic examination: an alternative to chest radiography after central venous catheter insertion? *Am J Respir Crit Care Med* 2001 164:403-405
- Mayo PH, Goltz HR, Tafreshi M & Doelken P. Safety of ultrasound-guided thoracentesis in patients receiving mechanical ventilation. *Chest* 2004 125(3):1059-1062
- Reissig A, Kroegel C: Transthoracic sonography of diffuse parenchymal lung disease: the role of comet tail artifacts. *J Ultrasound Med.* 2003 22:173-180
- Roch A, Bojan M, Michelet P, Romain F, Bregeon F, Papazian L, Auffray JP. Usefulness of ultrasonography in predicting pleural effusion > 500 mL in patients receiving mechanical ventilation. *Chest* 2005; 127:224-232
- Rowan KR, Kirkpatrick AW, Liu D, Forkheim KE, Mayo JR & Nicolaou S. Traumatic pneumothorax. Detection with thoracic US: Correlation with chest radiography and CT. *Radiology* 2002 225: 210-214
- Soldati G, Testa A, Silva FR, Carbone L, Portale G, Silveri NG: Chest ultrasonography in lung contusion. *Chest* 2006 130(2):533-538
- Via G, Lichtenstein D, Mojoli F, Rodi G, Neri L, Storti E, Klersy C, Iotti G & Braschi A. Whole lung lavage: a unique model for ultrasound assessment of lung aeration changes. *Intensive Care Med* DOI 10.1007/s00134-010-1834-4
- Vignon P, Chastagner C, Berkane V, Chardac E, Francois B, Normand S, Bonnard M, Clavel M, Pichon N, Preux PM, Maubon A, Gastinne H. Quantitative assessment of pleural effusion in critically ill patients by means of ultrasonography. *Crit Care Med* 2005;33:1757-1763
- Volpicelli G, Mussa A, Garofalo G, Cardinale L, Casoli G, Perotto F, Fava C, Frascisco M: Bedside lung ultrasound in the assessment of alveolar-interstitial syndrome. *Am J Emerg Med* 2006 24:689-696
- And many other publications, including the first international consensus conference (2012)

For making one step beyond

Detailed applications are available in “Whole body ultrasound in the critically ill” (2010, Springer, 4th Ed since 1992)

An adapted training to lung ultrasound at the bedside of the critically ill is accessible in medical ICU of Hospital Ambroise-Paré, using personalized approach of CEURF (www.ceurf.net)



CEURF (Cercle des Echographistes d'Urgence et de Réanimation Francophones) trains in french and in english. One didactic day details what is holistic critical ultrasound (and why the organs, applications and equipment permanently interact, creating *harmony*).

The bedside stage includes not more than two attendees, at the bedside. One (basic), two (advanced) or three (expert) mornings are possible.

After the session, CEURFers can communicate with the bureau with no limitation in time (advise on given patients, help in publications...).

A substitute product for gel is used at CEURF, allowing to make fast protocols (BLUE-protocol in 3 minutes or less).

CEURF is a non-profit association (1901 law), aiming at widespreading a different vision of ultrasound.



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