

2016년 대한흉부심장혈관외과학회 통합 학술대회 및 연수교육

**【2016년 초음파 연수강좌】**



## Basic Echocardiography

분당서울대학교병원 흉부외과학교실

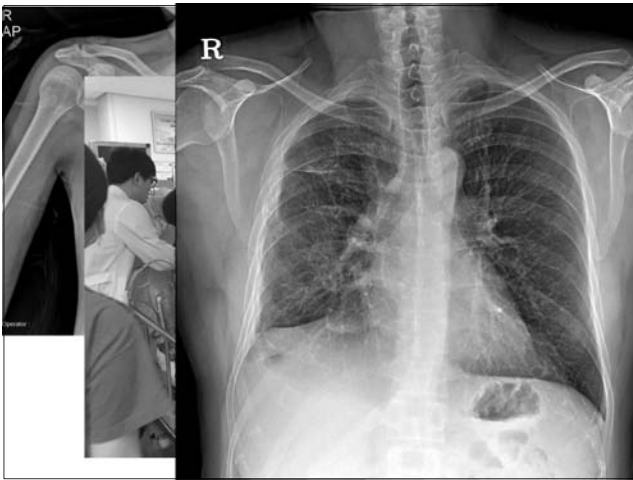
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# Lung Ultrasonography: Aspect of Intensive Care

Department of Thoracic and Cardiovascular Surgery, CNUH

Do Wan Kim



**FACTS-Care**  
The Only One Like Us

**Friday, October 2, 2015**

7:00 am – 8:00 am  
Light Breakfast & Registration

8:00 am – 8:30 am  
Update on New Oral Anticoagulants & Reversing Their Effects

8:30 am – 9:00 am  
Management of Complications in Cardiac Surgery Patients

9:00 am – 9:30 am  
Ethical Challenges of Advanced Critical Care Technology & Case Scenario

9:30 am – 10:00 am  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

10:00 am – 10:30 am  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

10:30 am – 11:00 am  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

11:00 am – 11:30 am  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

11:30 am – 12:00 pm  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

12:00 pm – 1:00 pm  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

1:00 pm – 2:15 pm  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

2:15 pm – 3:00 pm  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

3:00 pm – 3:30 pm  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

3:30 pm – 4:00 pm  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

4:00 pm – 5:30 pm  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

5:30 pm – 6:00 pm  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

6:00 pm – 6:30 pm  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

6:30 pm – 7:00 pm  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

7:00 pm – 7:30 pm  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

7:30 pm – 8:00 pm  
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11:00 pm – 11:30 pm  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

11:30 pm – 12:00 am  
Acute Renal Dysfunction & Failure in CVT ICU Patients - Early Diagnosis & Treatment

Think Difficult.

Think

Hold different.

## Seven principles

- Lung ultrasound is performed at best using simple equipment.
- Thorax, gas and fluids have opposite locations, or are mingled by pathologic processes, generating artifacts.
- The lung is the most voluminous organ. Standardized areas can be defined.
- All signs arise from the pleural line.
- Static signs are mainly artifactual.
- The lung is a vital organ. The signs arising from the pleural line are foremost dynamic.
- Almost all acute life-threatening disorders about the pleural line, explaining the potential of lung ultrasound.

Lichtenstein DA. Lung ultrasound in the critically ill. Ann Intensive Care. 2014 Jan 9;4(1):1.

## Principle

- 5-MHz Microconvex/Linear probe ( 4 -12 MHz )
  - 1 -17cm range of exploration
- Turn off filters : for artifacts
- Normal lung : invisible
- Air : non transmitter
- Fluid : good mediator
- Pneumothorax : interrupt of visceral pleura
- Pleural effusion : identification of visceral pleura

## Principle

- High frequency (5 -10 MHz)
  - Greater resolution
  - Less penetration
  - Superficial structure
- Lower frequency (2 – 3.5 MHz)
  - Greater penetration
  - Less resolution
  - Deep structure

## Check point

- Boundary
  - Sternum
  - Anterior axillary line
  - Posterior axillary line
- Area
  - Upper BLUE point
  - Lower BLUE point
  - PLAPS (Posterior/ Lateral, Alveolar / Pleural syndrome) point

## BLUE point



Lichtenstein DA. The BLUE-points: three standardized points used in the BLUE-protocol for ultrasound assessment of the lung in acute respiratory failure. Crit Ultrasound J (2011) 3:109-110

## BLUE point

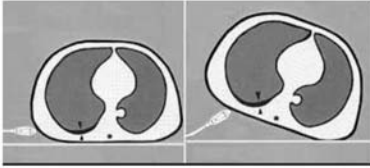


Lichtenstein DA. The BLUE-points: three standardized points used in the BLUE-protocol for ultrasound assessment of the lung in acute respiratory failure. Crit Ultrasound J (2011) 3:109-110

## PLAPS-point

- Posterior axillary line + Lower BLUE point
- Alveolar syndrome : consolidation
- Pleural syndrome : pleural fluid
- Milestone of pleural effusion
- The lowest point of the lung
- BLUE protocol : not pulmonary edema but pneumonia

## Lateralization maneuver



- Small amount pleural effusion
- Posterolateral consolidation

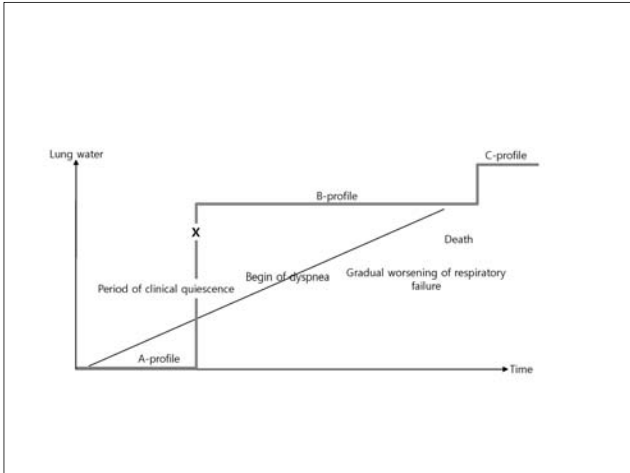
Lichtenstein DA. Introduction to Lung Ultrasound.  
Whole Body Ultrasonography in the Critically Ill, page 117-127



## Manipulation

- Correct angle – right angle of pleura
- Zero pressure
- Pleural line : 0.5 cm below the rib line
- Distance of the ICS : 2 cm
- Neonate : Same as adult





## 10 signs

- Bat sign
- A line
- Lung sliding
- Stratosphere sign
- Lung point
- Sinusoid sign
- Quad sign
- Shred sign
- Tissue like sign
- B line

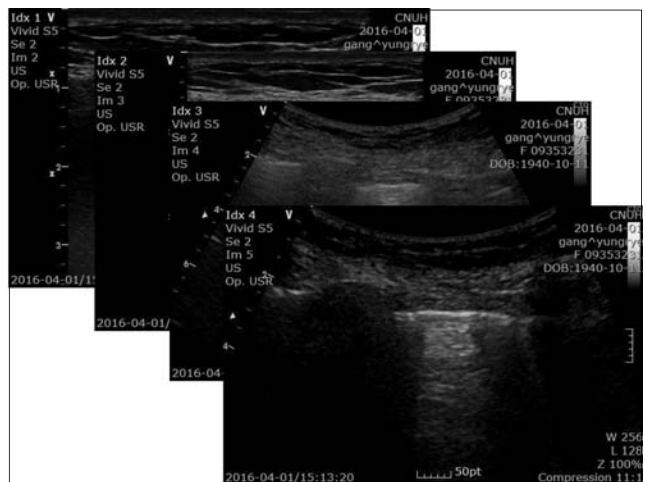
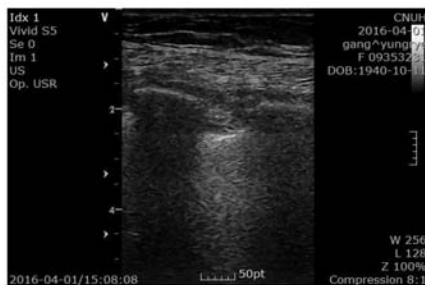
## 10 signs

- Location of the lung : Bat sign
- Normal lung surface : Lung sliding, A-lines
- Pleural effusion : Sinusoid sign, Quad sign
- Alveolar consolidation : Shred sign, Tissue like sign
- Interstitial syndrome : Lung rockets
- Pneumothorax : Lung point, Stratosphere sign

## Bat sign

- Location of the lung – 1<sup>st</sup> sign, landmark
- Upper rib, lower rib, pleural line
- Pediatrics : same as adult
- Normal : do not distinguish visceral and parietal pleura
- More important indicator than lung sliding sign

## Bat sign ??



### Bat sign

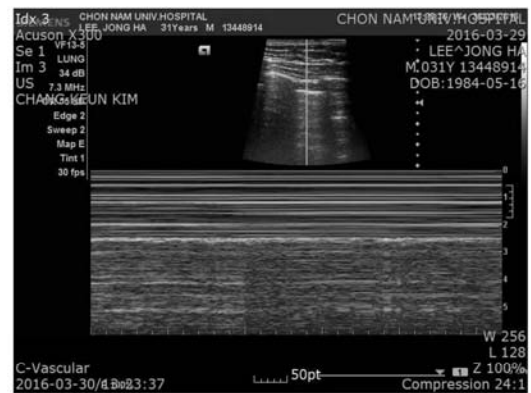
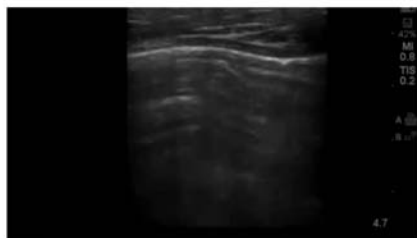
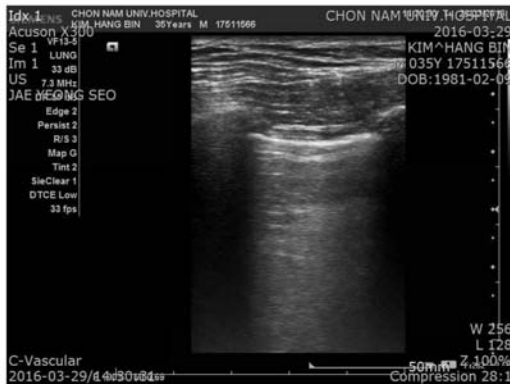


### A-lines

- First letter of Alphabet
- Horizontal, Reverberations, Motionless
- Manifestation of air
- Only finding in two third of normal lung
- A-line + lung sliding = A profile
- A-line only without sliding = A' profile

### Lung sliding

- Pleural sliding (visceral pleura movement)
- Lung touching chest wall
- Greatest in lower thorax
- Absence : pneumothorax, intrathoracic adhesion, critical parenchymal disease, esophageal intubation
- M-mode : Seashore sign





### B-lines

- **Comet-tail sign : water contained anatomy**
- **Originates from pleura**, absence of air
- Hyperechoic, vertical narrow bands
- Obliterate A-line, move with lung sliding
- 3 more at once : abnormal interstitial pathology, lesion in alveoli, lung rockets
- Join of B-lines : severity

### B-lines

- Interstitial syndrome
- 3 at once > B line
- 2 at once < b line, maybe fissure
- B-pattern : multiple B-lines with interstitial syndrome
- Sub B-line : pleural effusion ( compression of normal lung tissue)

### Lung rockets

- PLAPS point : non specific (d/t gravity)
- Bilateral all fields : cardiogenic edema
- Localized : consolidation (pneumonia, interstitial diseases)
- Lung rockets + lung sliding = B profile
- Lung rockets without sliding = B' profile



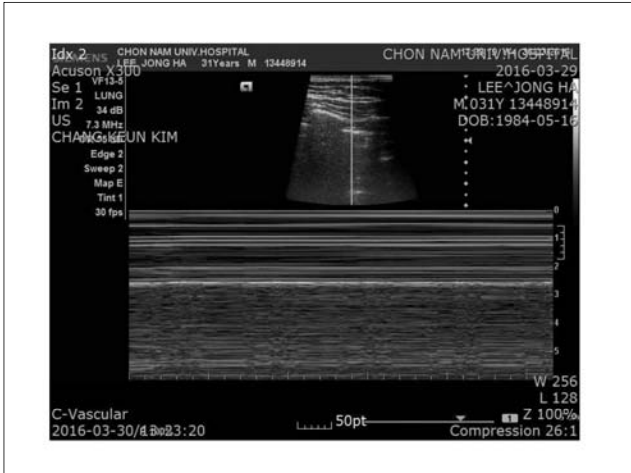
### B-lines



Lichtenstein DA. Relevance of lung ultrasound in the diagnosis of acute respiratory failure: the BLUE protocol. Chest. 2008 Jul;134(1):117-25.

### Stratosphere sign

- Barcode sign
- Absence of lung sliding
- D/D with lung pulse
- Pneumothorax in M mode



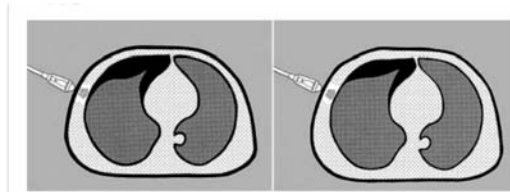
## Lung point

- Indicator of pneumothorax
- Abrupt appearance
- Lateral side : Pneumothorax size ↑
- On one side : lung sliding preserve
- On the other side : lung sliding absent
- Pneumothorax with no lung point : massive pneumothorax (total collapse)

## Lung point

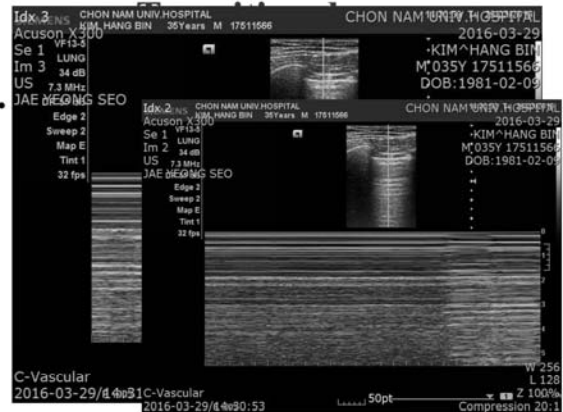
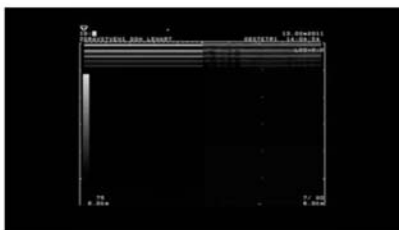
- End expiration or inspiration pause
- Moderate use of M-mode
- Progressive pattern
- Entire lung area

## Lung point



<http://www.emcurious.com/blog-1>

## Lung point

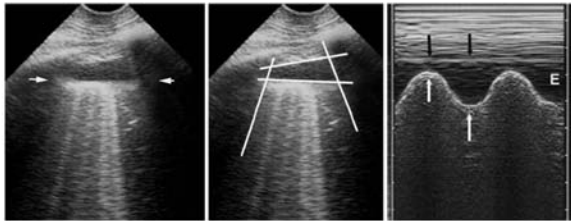


### Quad sign

- PLAPS point
- Dependent position
- Static sign, pleural and lung line, rib
- Deep boundary of the collection : regular
- Roughly parallel to the pleural line
- Sub B-lines

### Sinusoid sign

- Dynamic sign
- The respiratory shift of the pleural line
- Small amount of effusion : lung inflation of inspiratory phase → "no show"
- M mode : sine curve
- Indicates a low viscosity, no septation

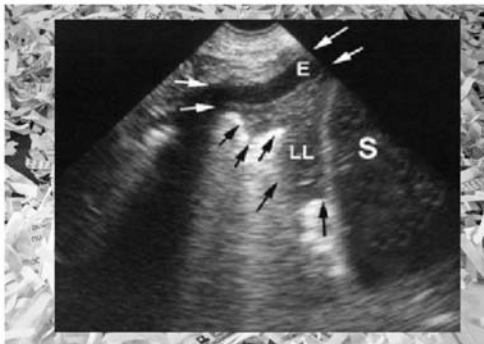


Lichtenstein DA. Lung ultrasound in the critically ill. *Annals of Intensive Care* 2014, 4:1

### Shred sign

- Alveolar consolidation
- More common
- Boundary – pleural line, air-consolidative border
- Fractal line
- The nontranslobar sign of consolidation
- Mixed pattern : aerated lung and consolidation
- Tissular pattern

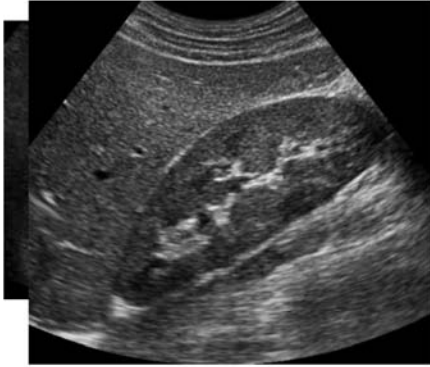
### Shred sign



### Tissue like sign

- The sign of translobar consolidation
- Hepatization
  - Disorder looking like a solid organ
- No sinusoid sign : a size remains steady
- No fractal line

### Tissue like sign



### BLUE-protocol

- Acute respiratory failure
- Very fast (< 3 min.)
- Upper point : upper lobe
- Lower point : middle lobe, lingular segment
- PLAPS point : lower lobe

### Accuracy

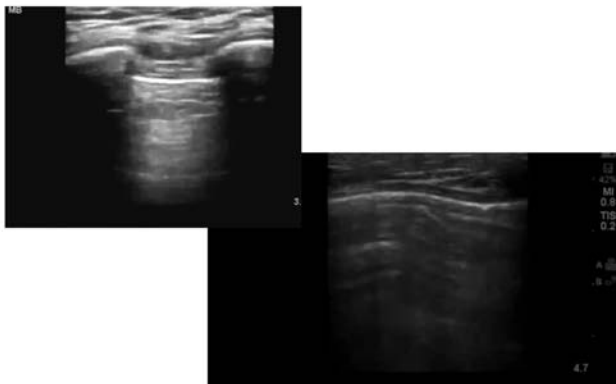
- U/S sensitivity : 98%
- U/S specificity : 95%
- X-ray sensitivity : 67%
- X-ray specificity : 85%

Francesca C, et al. Lung ultrasound is an accurate diagnostic tool for the diagnosis of pneumonia in the emergency department. Emerg Med J 2012;29:19-23

### Pneumothorax

- High frequency probe
- Disappearance of lung sliding
- Presence of lung point
- Evaluation of whole respiratory cycle
- Presence of B-line : r/o pneumothorax
- Supine : lower BLUE point
- Fowler's : upper BLUE point

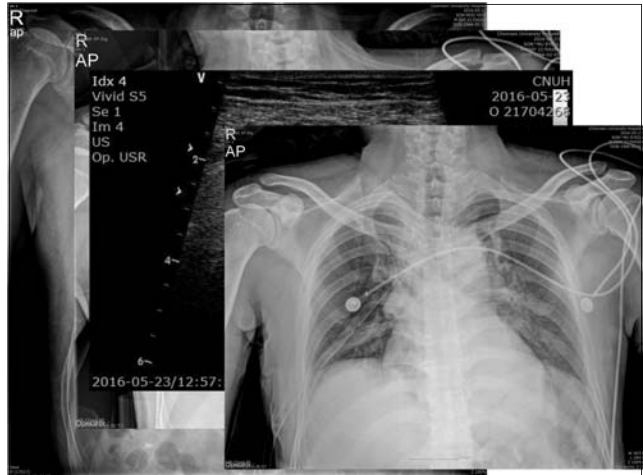
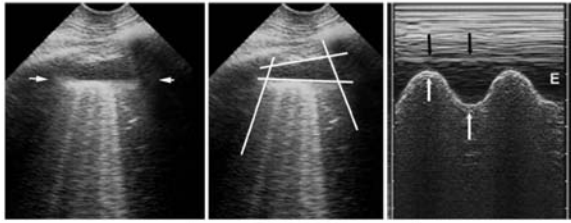
### Pneumothorax



### Pleural effusion

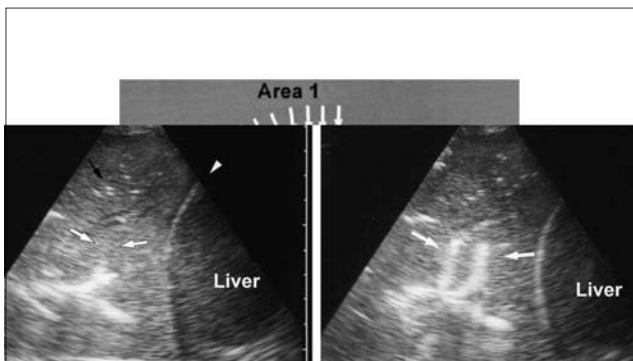
- Hypoechoic
- Amount : > 20ml
- The volume does change with respiration
- Quadrangular shape with a regular lower border
- Useful Indicator of drainage site
- Transudate : anechoic
- Exudate : echogenic feature
- Sub B-line

## Pleural effusion



## Alveolar syndrome

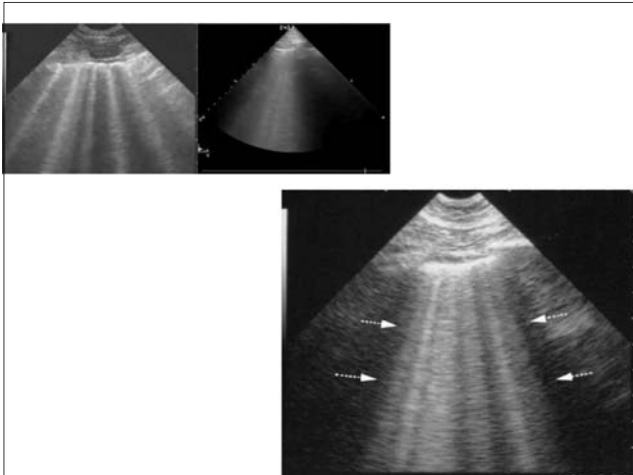
- Water contained alveoli
- m/c in PLAPS point
- Does not change with respiration
- D/D with abdominal organ (etc liver.)
- Visible state of lung tissue
- Hepatization
  - Consolidated lung looks like liver
  - Air bronchogram indicate parenchymal syndrome



Lichtenstein DA. Ultrasound diagnosis of alveolar consolidation in the critically ill. Intensive Care Med (2004) 30:276-281

## Interstitial syndrome

- Thickened interlobular septum
- B-lines, Lung rockets sign
- Upper and lower BLUE point
- B1 = 7mm apart (moderate air loss)
- B2 = 3mm apart (severe air loss)
- D/D with Z-line
- PLAPS point : less clinical importance

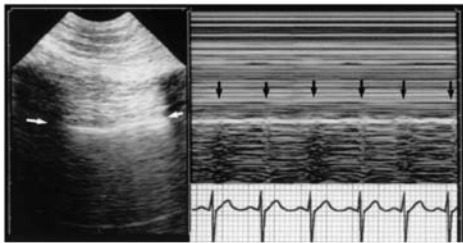


## Lung pulse

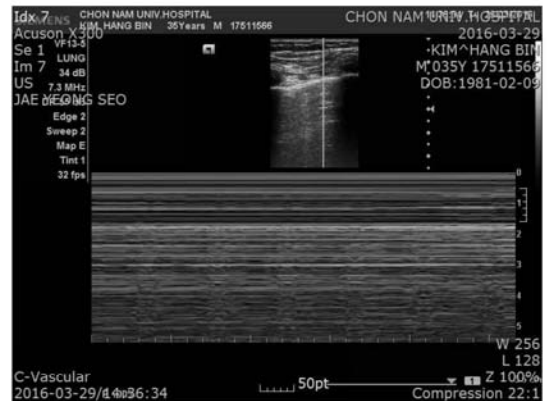
- Disappearance of lung sliding
- Heart beating
- r/o pneumothorax
- D/D pneumothorax : no lung pulse
- Atelectasis : selective intubation, ARDS

Lichtenstein DA, et al. The "lung pulse": an early ultrasound sign of complete atelectasis. Intensive Care Med. 2003 Dec;29(12):2187-92.

## Lung pulse



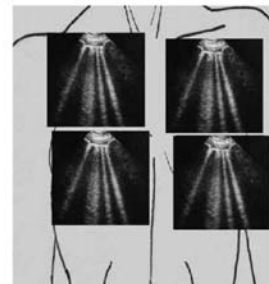
Lichtenstein DA, et al. The "lung pulse": an early ultrasound sign of complete atelectasis. Intensive Care Med (2003) 29:2187-2192



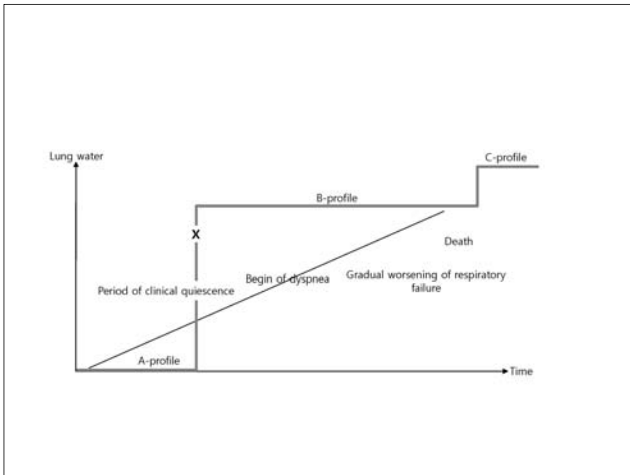
## Pulmonary edema

- Anterior-predominant bilateral B line ( more > 4)
- Presence of lung sliding
- B-profile
- Smooth pleura
- Abrupt onset of B-line : endpoint of fluid therapy
- Proceed to C-profile

## Pulmonary edema



Lichtenstein DA. Relevance of lung ultrasound in the diagnosis of acute respiratory failure: the BLUE protocol. Chest. 2008 Jul;134(1):117-25.



## Lung contusion

- Alveolar interstitial syndrome
- Increased lung water

Lichtenstein DA. The Comet-tail artifact. American Journal of Respiratory and Critical Care Medicine. 1997 156 (5): 1640-1646.

## FALLS-Protocol

- Not yet supported by clinical trials
- Pulmonary artery occlusion catheter
- Dichotomy
- Change of A-lines to lung rockets
- Direct biomarker of clinical status

FALLS-protocol

1) Ruling out obstructive shock

Simple cardiac sonography:  
Pericardial tamponade  
Right ventricle dilatation\*

BLUE-protocol: pneumothorax (A-profile)

2) Ruling out cardiogenic shock?

BLUE-protocol: pulmonary edema (B-profile)

3) Ruling out hypovolemic shock (A-profile)

Correction of parameters of shock  
under fluid administration

4) Detecting distributive shock, septic shock currently

Fluid therapy not able to improve  
circulation, eventually generating  
a B-profile

Lichtenstein DA. BLUE-protocol and FALLS-protocol: two applications of lung ultrasound in the critically ill. Chest. 2015 Jun;147(6):1659-70.

## Hyponatremia

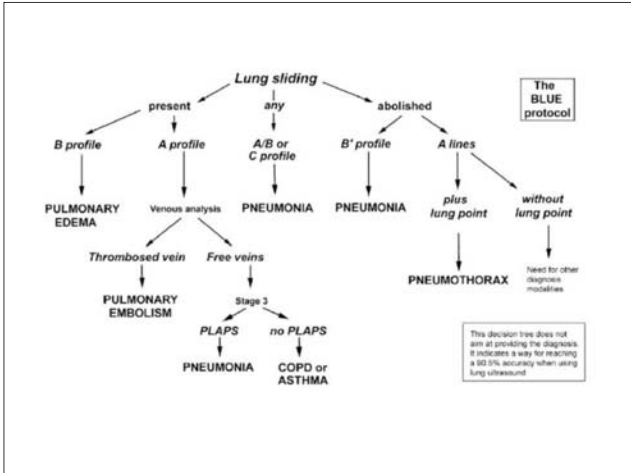
- Assessment of volume state
- Hypovolemic hyponatremia : A-line (dry lung)
- Dilutional hyponatremia : B-line (hypervolemia)
- Fast lung rockets sign, before respiratory symptom

## Procedure

- Safest window
- Quad and sinusoid sign
- Fluid visible over 3 intercostal space
- 15 mm distance (interpleura) is minimum required
- Patient position : dorsal, lateral decubitus

Lichtenstein D, et al. Feasibility and safety of ultrasound-aided thoracentesis in mechanically ventilated patients. Intensive Care Med. 1999 Sep;25(9):955-8.

Diagnoses	Methods
For all patients	History, clinical examination, radiography read by radiologists, CT when available (n = 38), favorable clinical progression under treatment, and:
Cardiogenic pulmonary edema (referred to as pulmonary edema) (n = 64)	Evaluation of cardiac function using echocardiography, functional tests, and American Heart Association recommendations
Pneumonia (n = 53)	Infectious profile, radiologic asymmetry, microorganism isolated (blood, invasive tests), recovery with antibiotics. Included were infectious, aspiration, community, or hospital-acquired pneumonia. Pneumonia complicating chronic respiratory disease was classified as pneumonia. Beginning AIDS (n = 7) and massive atelectasis (n = 1) were included in this group
Decompensated chronic respiratory disease (referred to as COPD) (n = 49)	Condition defined as exacerbation of chronic respiratory disease without pneumonia, pneumothorax, pulmonary edema, pleurisy, or pulmonary embolism. COPD was confirmed by functional tests. Patients with simple bronchial superinfection were classified in this case. COPD patients with pneumonia, pneumothorax, etc. were first considered as pneumonia, pneumothorax, etc.
Acute asthma (n = 34)	History, response to bronchodilator treatment
Pulmonary embolism (n = 21)	Helical CT
Pneumothorax (n = 9)	Radiography (CT if necessary)
Excluded patients	
Rare (<2%) causes (n = 9)	Chronic diffuse interstitial disease (n = 4), massive pleural effusion (n = 3), fat embolism (n = 1), tracheal stenosis (n = 1). Note: no dyspnea due to pericardial effusion in this consecutive series
No final diagnosis (n = 16)	Unknown diagnosis at the end of hospitalization, progression preventing conclusions
Several final diagnoses (n = 16)	Pulmonary edema plus pneumonia (n = 10), pulmonary edema plus COPD (n = 3), others (n = 3)



- ### BLUE protocol
- Lung rockets : only anterolateral part
  - Pulmonary edema : diffuse B-line + lung sliding
  - Pneumothorax : A-line + Lung point + sliding(-)
  - Pneumonia : B-pattern + sliding(-), A-profile +PLAPS, A/B profile, C-profile

- ### Limitation
- Do not evaluation of trachea
  - Chest tube
  - Dressing
  - Subcutaneous emphysema
    - No Bat sign
    - E-lines
  - Huge bullae
    - finding of lung sliding
    - D/D with pneumothorax





## Sono-guided Vascular Access and Intervention

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김 재 범

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