

# Hrudní sonografie – update 2022

Martin Balik

Dept. of Anaesthesia and Intensive Care

1<sup>st</sup> Medical Faculty, Charles University, General University Hospital  
Prague, European Union

# Konzept bedside CUS a echokardiografie

- LV function and determination of LVEDP/LAP, mitral valve

**OXFORD** OXFORD TEXTBOOKS IN CRITICAL CARE

Huang et al. *Ann. Intensive Care* (2020) 10:49  
<https://doi.org/10.1186/s13613-020-00662-y>

*Intensive Care Med*  
<https://doi.org/10.1007/s00134-020-06262-5>

**CONFERENCE REPORTS AND EXPERT PANEL**

## The PRICES statement: an ESICM expert consensus on methodology for conducting and reporting critical care echocardiography research studies

Filippo Sanfilippo<sup>1</sup>, Stephen Huang<sup>2</sup>, Antoine Herpain<sup>3</sup>, Martin Balik<sup>4</sup>, Michelle S. Chew<sup>5</sup>, Fernando Clau-Terré<sup>6</sup>, Carlos Corredor<sup>7</sup>, Daniel De Backer<sup>8</sup>, Nick Fletcher<sup>9</sup>, Guillaume Geri<sup>10,11</sup>, Armand Mekontso-Dessap<sup>12</sup>, Anthony McLean<sup>2</sup>, Andrea Morelli<sup>13</sup>, Sam Orde<sup>2</sup>, Tatjana Petrinic<sup>14</sup>, Michel Slama<sup>15</sup>, Iwan C. C. van der Horst<sup>16</sup>, Philippe Vignon<sup>17</sup>, Paul Mayo<sup>18</sup> and Antoine Vieillard-Baron<sup>10,11\*</sup>

### Critical Care Echocardiography

EDITED BY  
**Anthony McLean**  
**Stephen Huang**  
**Andrew Hilton**

ALL CONTENT AVAILABLE AT [OXFORDMEDICINE.COM](http://OXFORDMEDICINE.COM)

21  
**Acute respiratory failure**  
Annals of Intensive Care

Open Access  
Check for updates

ing port e

relative contributions of LAP, volume state, and LV ventricular dysfunction to any respiratory failure [4]. Importantly, this may affect management of the respiratory failure in terms of fluid loading and diuresis strategy at the bedside (see Case 21.1).

#### Assessment of LV function

It is important to appreciate that patients with chronic left heart disease may present with non-cardiac acute respiratory failure, and that pre-existing disease may complicate their clinical cause and management. Furthermore, a chronic cardiac patient may suffer from respiratory failure in the absence of elevated cardiac filling pressures and should not be denied preload substitution if a volume-responsive shock status is revealed (see Case 21.2). Also the absence of echocardiographic LV systolic failure doesn't exclude alternative cardiac causes for pulmonary oedema, including diastolic failure, arrhythmias, and mitral or aortic valve disorders.

#### Assessment of LAP

LAP can be assessed by various Doppler modalities (Table 21.1). Pulsed-wave Doppler of transmitral LV filling velocities is an acquired measure which reflects the magnitude and temporal course of the LA-LV pressure gradient across the mitral orifice in diastole [5]. This is affected by volume state (preload), left ventricular afterload and left ventricular diastolic function (i.e. active relaxation and passive filling, mitral valve and left atrial performance). The latter is affected by the volume state and the presence of mitral regurgitation.

On the other hand, acute respiratory failure may be associated with acute right heart failure, either as a direct consequence of the primary cause (e.g. acute pulmonary thromboembolism) or as a complication of deleterious heart-lung interactions associated with inappropriate ventilator settings [3].

Various echocardiographic and Doppler parameters can be used to assess LAP and right heart function and help differentiate between non-cardiac causes of acute respiratory failure. Furthermore, lung ultrasonography can help in this distinction and even diagnose specific pulmonary causes.

#### Circulatory instability as a cause of respiratory failure

A possible approach to the echocardiographic assessment of the critically ill patient with respiratory failure begins with an assessment of left ventricle (LV) function and estimate of LAP. This identifies the

18

Publ. Feb.-Mar. 2020

- Indication to ECMO (TTE+LUS....)

# Echo a CUS in a respiratory failure

What is LVEDP and LAP ?

Improvement in preload, contractility, afterload and heart rate/rhythm ?

Cardiac failure, could the symptoms be relieved by mechanical ventilation ?

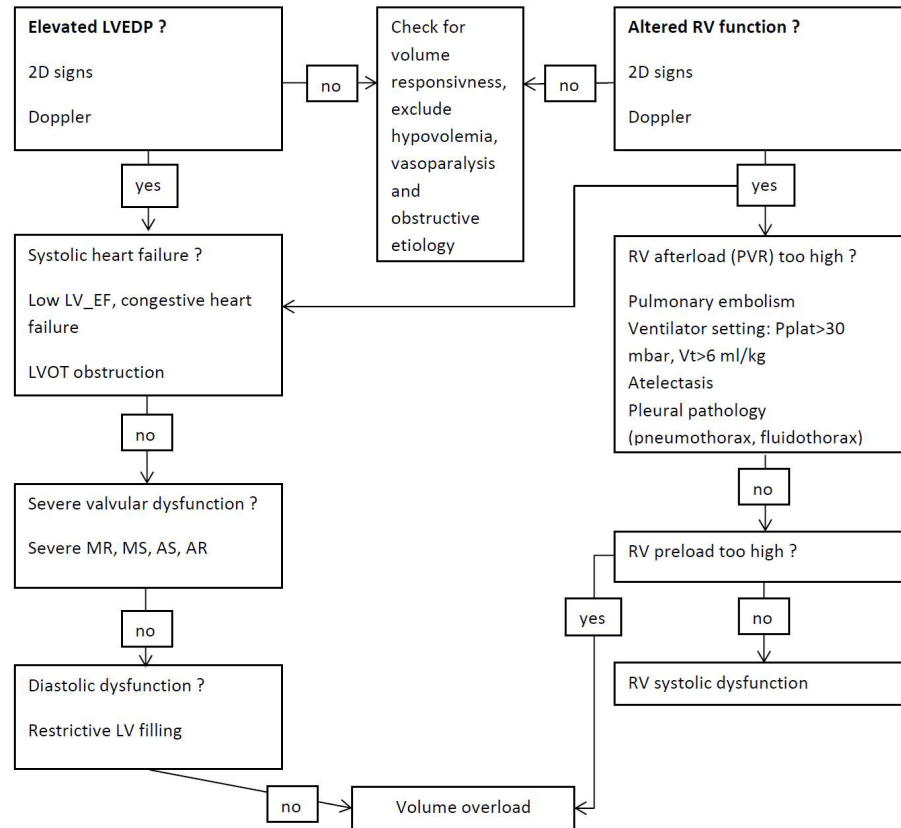
RV/RA function to tolerate IPPV ?

Is the lung recruitable ? How to set a ventilator ?


Patient's position ? Is the pleural drainage feasible ? Is a fiberoptic bronchoscopy indicated ?

Is there an indication to ECLS ? What type of ECLS and what cannulation ? An optimal IPPV during ECLS ?

Acute respiratory failure and circulatory instability




# Systematic approach to chest US: 12 zones



## LUNG ULTRASOUND

*Report Form*



PATIENT NAME: ..... GENDER:  M  F DATE OF BIRTH: .....

OPERATOR: ..... EXAM DATE: ..... HOUR: ..... STORAGE CODE: .....

HISTORY: .....

---

SPONT VENTILATION: RR = ..... Resp Distress:  Yes  No DECUBITUS:  Sup  Lat  Pron  Semirec

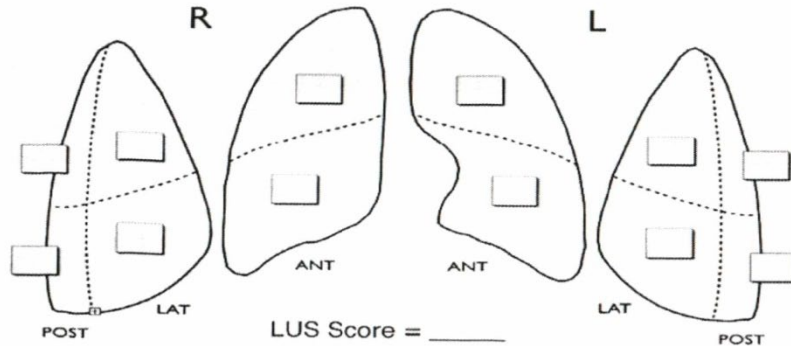
MECH VENTILATION: a) Modality:  PCV  DuoPAP  ASV  PSV  SIMV  NIV  CPAP

b) Settings/Pattern: PEEP/Ps = ..... / ..... Ppeak ..... Pplat ..... RR ..... I:E ..... VT .....

EGA/EAB: pH ..... pCO2 ..... HCO3- ..... BE ..... PO2 ..... P/F ..... SpO2% ..... Hb .....

INDICATION:  DIAGNOSTIC  SCREENING  MONITORING  PROCEDURAL GUIDANCE

TYPE OF EXAM:  simplified  comprehensive  focused (ANT / POST)



**Legenda:** 0 = A-Pattern (or nearly normal); 1 = B-Pattern (B-lines >3/field, well spaced); 2 = B-Pattern (crowded, coalescent +/- subpleural consolidations) 3 = Consolidation\* E= Effusion\*; Pn = Pneumothorax\*\*;  
 NS= Sliding Abolition; LP=Lung Pulse \*(3 and E: characterize below in description) \*\*(Indicate Lung Point(s) )

DESCRIPTION .....

.....

.....

DIAGNOSIS .....

Suspected  Not made  Second Opinion needed

-----  
Signature

Right:

Upper: Ant – Lat – Post

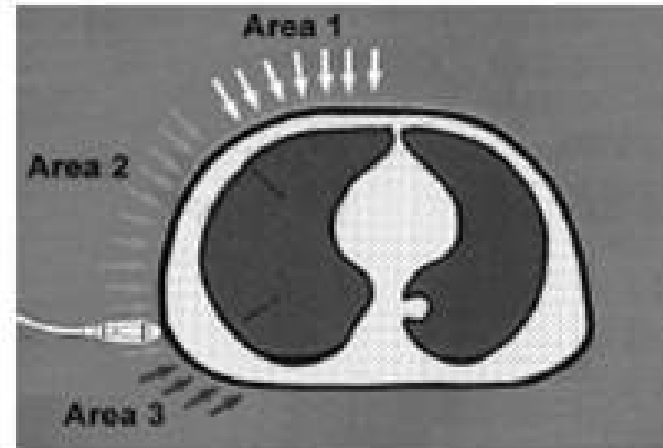
Lower: Ant – Lat – Post

Left:

Upper: Ant – Lat – Post

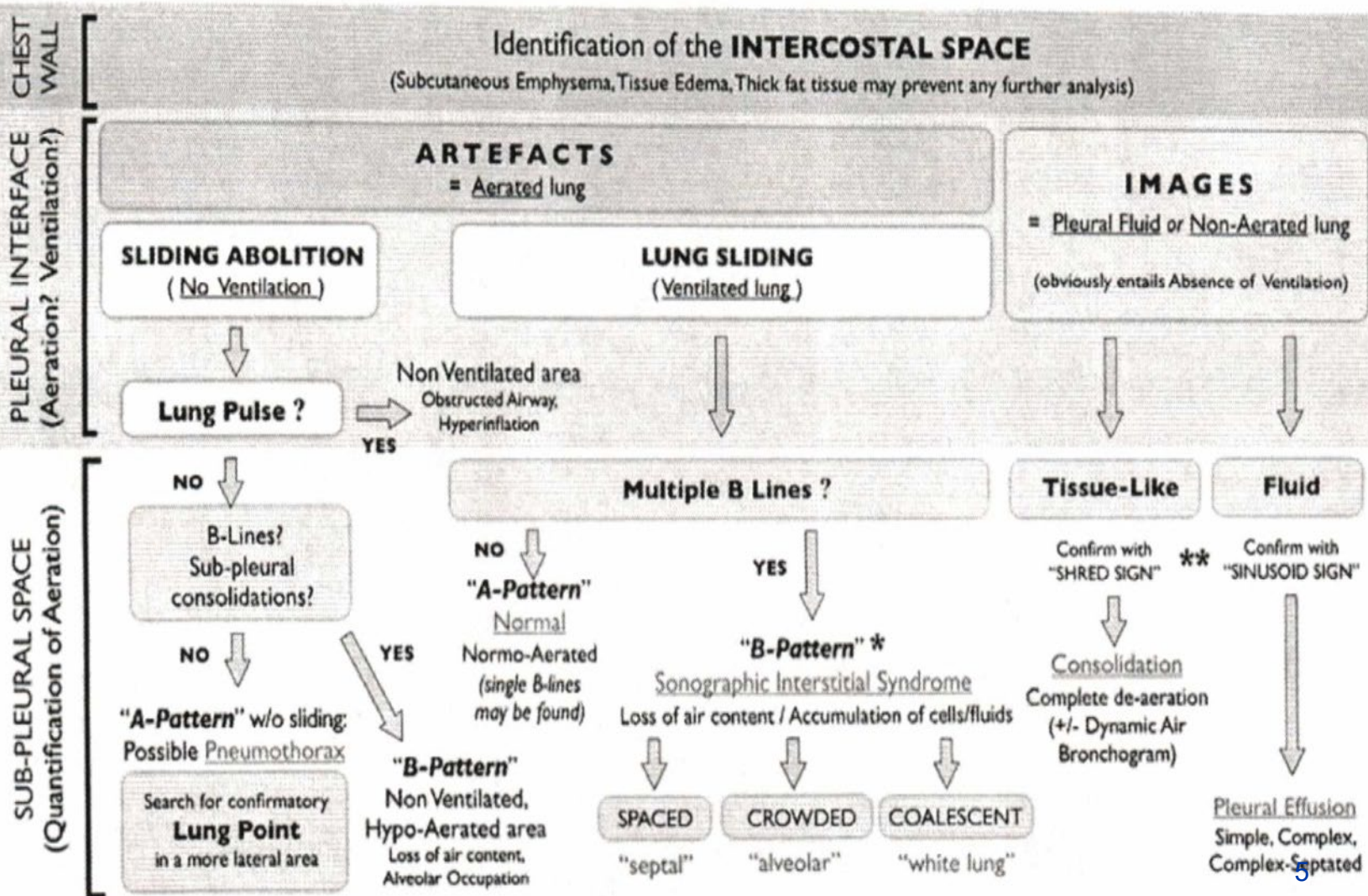
Lower: Ant – Lat – Post

(Via G, et al: Minerva Anesthesiol 2012)



# Sequential interpretation of chest US

(Via G, et al: Minerva Anestesiol 2012; 78: 1282-96)



# Detection of pleura, pulse, sliding, A a B lines

A line: reverberation of pleural line

B line: interlobular septa, >3.....  
accumulate fluid, 25-28%  
above diaphragm on IPPV

- ALI, ARDS
- card. lung edema
- pneumonia
- chronic interst. process

Heralds X-ray edema  
(Badgett RG 1996,  
Lichtenstein 2005, 2007)

Interstitial syndrome - grading

# 4 degrees of lung consolidation

I (**N**) – A lines, aerated lung, a comet, Z lines acceptable

II (**B1**) - B lines, up to B4-7 mm, A line absent

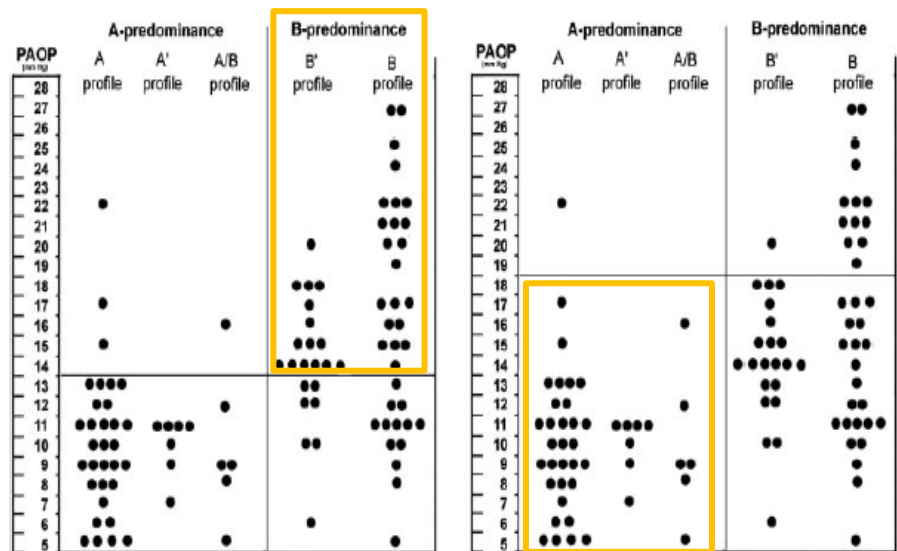
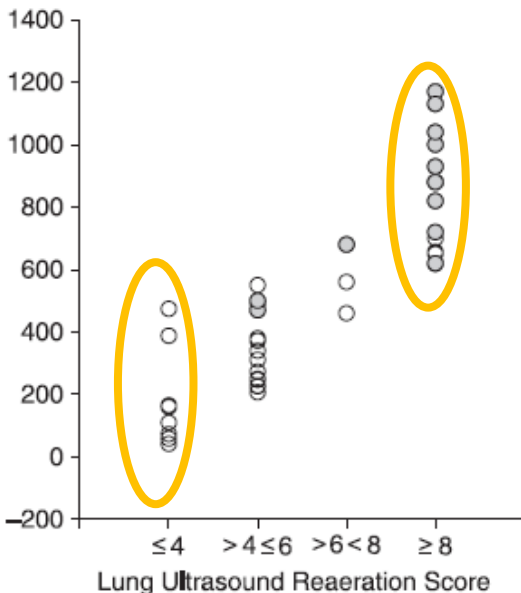
III (**B2**) – B lines 3 mm to coalescent

Recruitability II and III, seldom IV anterior, lateral  
Never IV basal and caudal ! (Bouhemad B: AJRCCM 2011)

# Kumulace tekutiny, rekrutabilita a preload

- **ARDS: correlate (weak) with EVLW** (Baldi G: Intens Care Med 2013)
- **No correlation to oxygenation** (Haddam M, Intensive Care Med 2016)
- **Monitoring of proning and positioning** (Tsubo T: Crit Care Med 2004)
- **Monitoring of ATB and th of VAP** (Bouhemad B, Crit Care Med 2010)
- **Prediction of SBT failure** (T-piece in intubated)
- **Derecruitment anterior, lateral, posterior** (Soummer A: Crit Care Med 2012)

**B** PEEP-induced Lung Recruitment (ml)



Daniel Lichtenstein: Chest 2009



## Multi-organ Point of Care Ultrasound for COVID-19 (PoCUS4COVID): Evidence and International Recommendations for the Front-line Clinician

Arif Hussain<sup>\*#1</sup> and Gabriele Via<sup>\*2</sup>, Lawrence Melniker<sup>3</sup>, Alberto Goffi<sup>4</sup>, Guido Tavazzi<sup>5</sup>, Luca Neri<sup>6</sup>, Tomas Villen<sup>7</sup>, Richard Hoppmann<sup>8</sup>, Francesco Mojoli<sup>9</sup>, Vicki Noble<sup>10</sup>, Laurent Zieleskiewicz<sup>11</sup>, Pablo Blanco<sup>12</sup>, Irene W.Y. Ma<sup>13</sup>, Mahathar Abd. Wahab<sup>14</sup>, Abdulmohsen Alsaawi<sup>15</sup>, Majid Al Salamah<sup>16</sup>, Martin Balik<sup>17</sup>, Diego Barca<sup>18</sup>, Karim Bendjelid<sup>19</sup>, , Belaid Bouhemad<sup>20</sup>, Pablo Bravo-Figueroa<sup>21</sup>, Kaour Breitkreutz<sup>22</sup>, Juan Calderon<sup>23</sup>, Jim Connolly<sup>24</sup>, Roberto Copetti<sup>25</sup>, Francesco Corradi<sup>26</sup>, Anthony J. Dean<sup>27</sup>, André Denault<sup>28</sup>, Deepak Govil<sup>29</sup>, Carmela Graci<sup>30</sup>, Young-Rock Ha<sup>31</sup>, Laura Hurtado<sup>32</sup>, Toru Kamada<sup>33</sup>, Michael I

Crit Care 2020

2 round Delphi,  
voting on PICO in 9

domains

DOMAIN	PoCUS APPLICATION
1	DIAGNOSIS OF SARS-COV2 INFECTION
2	TRIAGE/DISPOSITION
3	DIAGNOSIS OF COVID-19 PNEUMONIA
4	CARDIOVASCULAR DIAGNOSIS
5	SCREENING AND DIAGNOSIS OF THROMBOEMBOLIC DISEASE
6	PoCUS AND RESPIRATORY SUPPORT STRATEGIES
7	MANAGEMENT OF FLUID ADMINISTRATION
8	MONITORING OF COVID-19 PATIENTS
9	INFECTION CONTROL, TECHNIQUES, TECHNOLOGY AND PROTOCOLS

anspa<sup>34</sup>, Christian  
torfano<sup>39</sup>, Peiman  
ji Osman<sup>44</sup>, José  
elaert<sup>49</sup>, Susanna  
'ale Tung Chen<sup>55</sup>,


- **CUS je přesnější než RTG pro dg. respir. insufficience**
- **B linie, ztluštění pleury, subpleur konsolidace**
- **Konsolidace s bronchogramem hlavně u superinfekcí**
- **Bilat. A pattern vylučuje Covid19 pneumonii**
- **Integrace s klinikou a lab. dg. je krucální pro správnou interpretaci**

# Porovnání LUS a CT u Covid-19

## EDITORIAL

### Lung ultrasonography as an alternative to chest computed tomography in COVID-19 pneumonia?



Antoine Vieillard-Baron<sup>1,2</sup>, Alberto Goffi<sup>3,4</sup> and Paul Mayo<sup>5\*</sup> 

- **Problém v definici: Kolik B linií a jakou hustotu potřebujete ke korelátu s ground glass opacities ? .....coalescent B lines, gr.3 !**



# Důležitost illness severity pro dg. přesnost LUS

## ORIGINAL

Comparative study of lung ultrasound and chest computed tomography scan in the assessment of severity of confirmed COVID-19 pneumonia

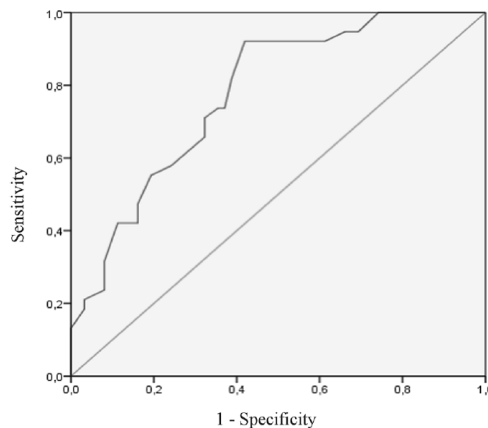


Laurent Zieleskiewicz<sup>1,2\*</sup>, Thibaut Markarian<sup>3</sup>, Alexandre Lopez<sup>1</sup>, Chloé Taguet<sup>3</sup>, Neyla Mohammadi<sup>1</sup>,

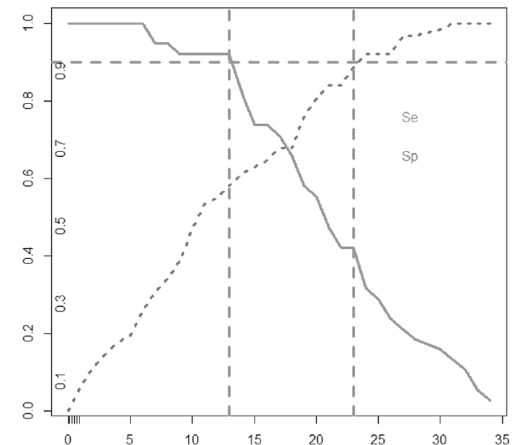
- 4 centra, 100 pts, LUS score ve 12 regionech: 0-36 (12x 0-1-2-3)
- AUC 0.78 (CI 95%, 0.68-0.87,  $p < 0.0001$ ), AUC 0.92 pro pac na UPV
- LUS > 23 predikce CT pneumonie se spec > 90%, PPV 70%
- LUS < 13 vylučuje CT pneumonii se spec > 90%, NPV 92%
- 38% inkonkluzivní,

skore 13-23...možná  
indikace k CT

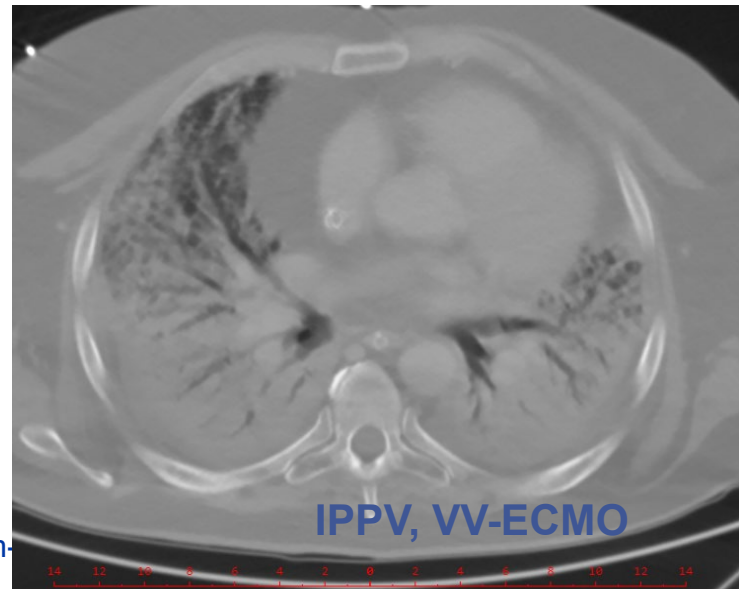
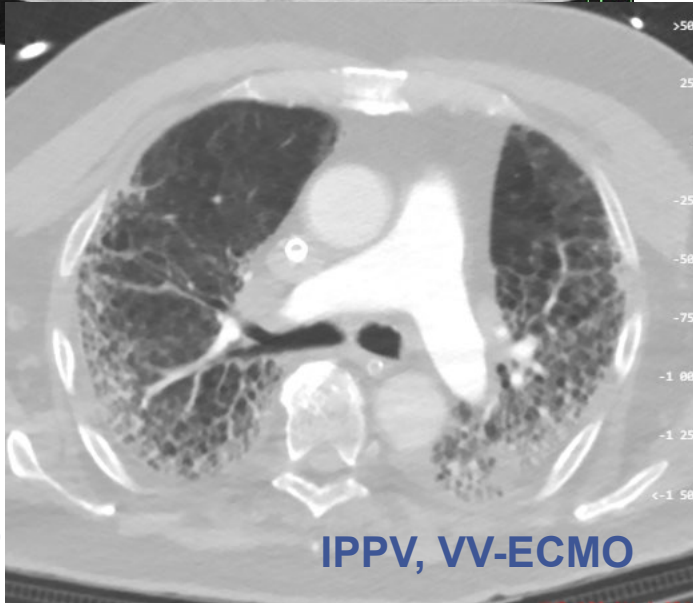
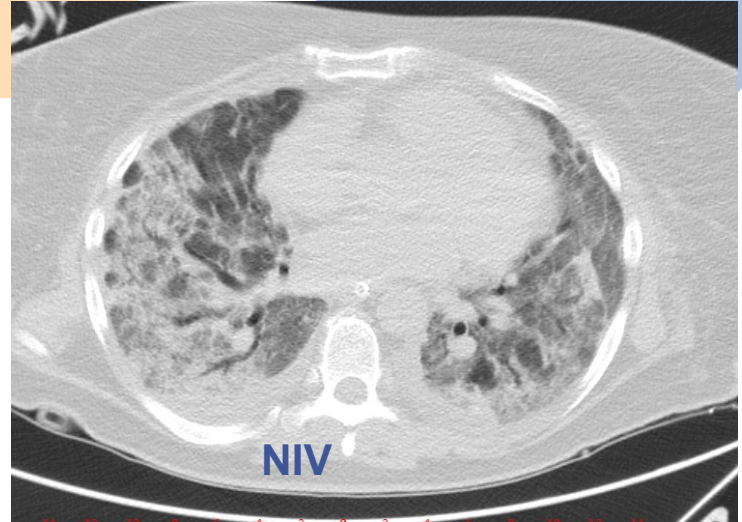
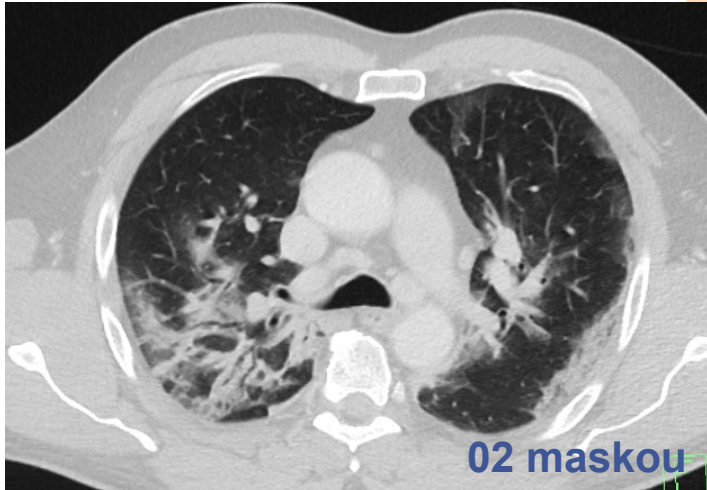
a ROC curve of LUS score versus chest CT scan



b Grey zone of LUS score versus chest CT scan



# 4 různí Covid-19 pacienti: Závažnost CT nálezu a korelace mezi LUS a CT



# CT není automatickou součástí diagnostiky těžkých intersticiálních plicních procesů

- CT jako možný indikátor ICU při příjmu (nebo standard ?) – ne prvních 48h
- neexistuje korelát mezi CT/RTG plicního parenchymu a funkčním stavem
- Tzv. procentuální výpočet zasažení plicního parenchymu nekoreluje s virovou náloží = neurčuje virostatickou léčbu
- Rutinní CT zatěžuje pacienta, RDG a ICU personál, pojišťovací systém (indukovaná léčba pro ICU...), spotřeby ochranných pomůcek....

(ACR Recommendations for the use of Chest Radiography and Computed Tomography (CT) for Suspected COVID-19 Infection, [www.acr.org](http://www.acr.org))

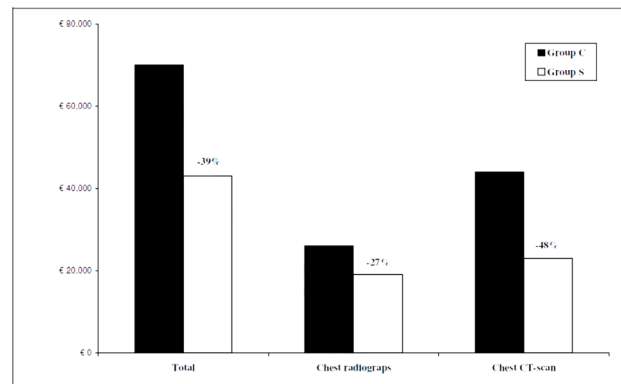
Intensive Care Med  
<https://doi.org/10.1007/s00134-021-06373-7>

ORIGINAL

## Lung ultrasound for the early diagnosis of COVID-19 pneumonia: an international multicenter study

Giovanni Volpicelli<sup>1\*</sup>, Luna Gargani<sup>2\*</sup>, Stefano Perlini<sup>3</sup>, Stefano Spinelli<sup>4</sup>, Greta Barbieri<sup>4</sup>, Antonella Lanotte<sup>5</sup>,

(Anesth Analg 2010;111:687–92)



ORIGINAL

# Lung ultrasonography for assessment of oxygenation response to prone position ventilation in ARDS



Malik Haddam<sup>1</sup>, Laurent Zieleskiewicz<sup>1</sup>, Sebastien Perbet<sup>2</sup>, Alice Baldovini<sup>1</sup>, Christophe Guerville<sup>3</sup>,



CUS: lokalizace  
konsolidované plíce pro  
dosažení maximálního  
benefitu polohování a  
pronace

**Conclusions:** In ARDS patients with a  $\text{PaO}_2/\text{FiO}_2$  ratio  $\leq 150$  mmHg, bedside LUS cannot predict oxygenation response after the first PP session. At the bedside, LUS enables monitoring of aeration changes during PP.

# Indication to bronchoscopy



- FOB 24/7 managed by intensivists
- Indication supported by imaging including ultrasonography
- Absence of dynamic bronchogram has 94% specificity for atelectasis (Lichtenstein D: Chest 2009)
- Positioning, proning, physiotherapy

+36h

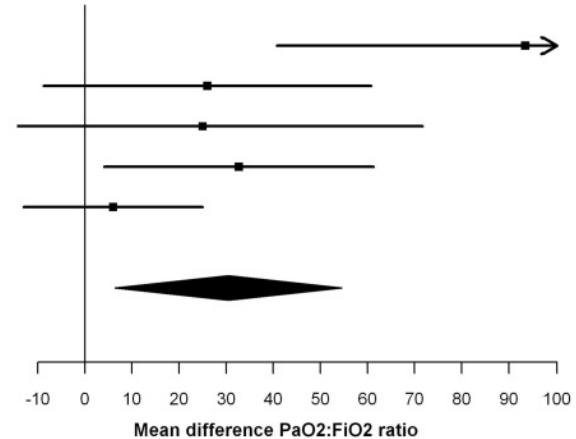


# Fluidothorax: Kvalitativní zhodnocení

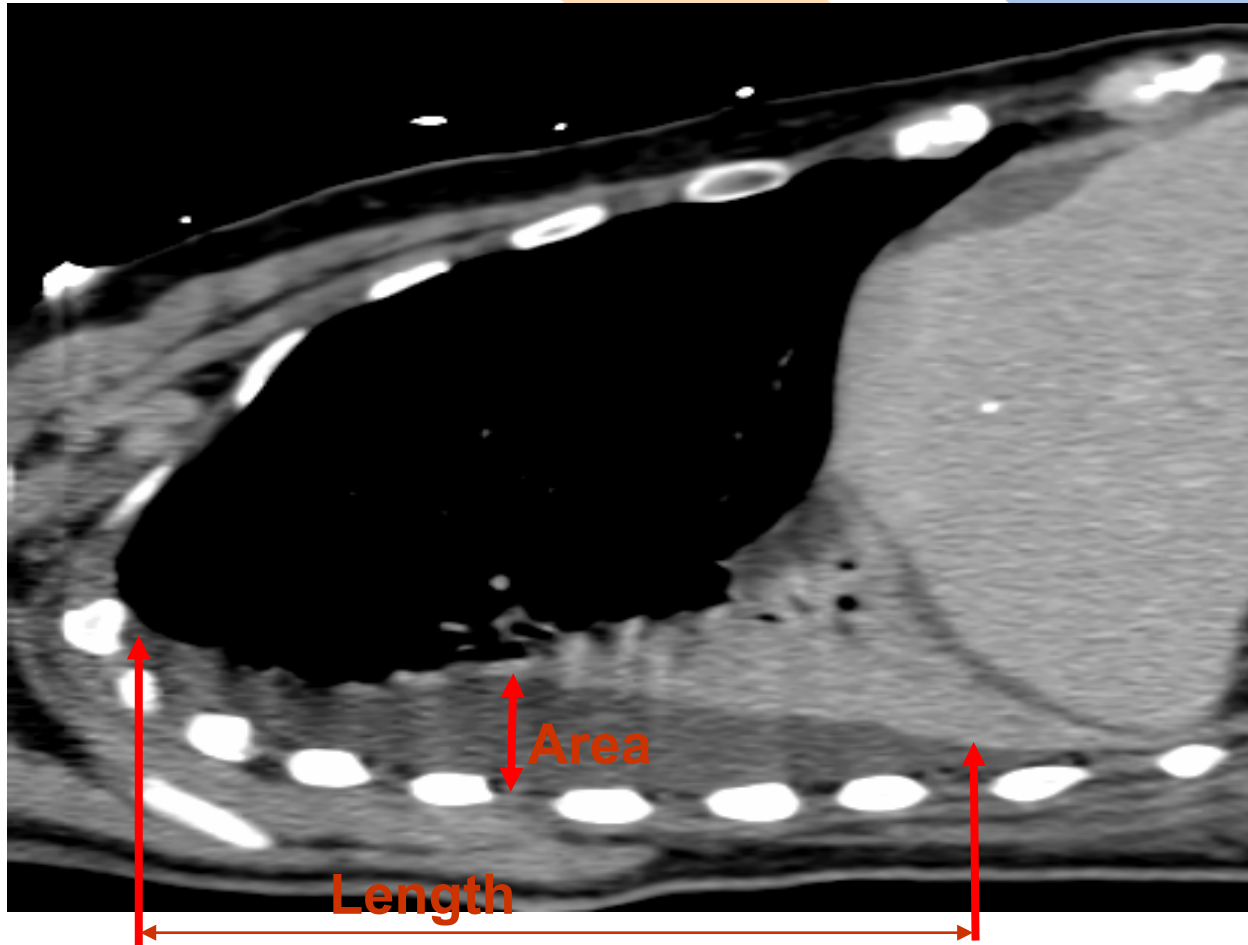


# Fluidothorax and favourable impact of drainage on oxygenation and weaning of IPPV

- 19 studies in metaanalysis of Goligher et al (Crit Care 2011):  $\text{paO}_2/\text{FiO}_2$  increase by 18% after drainage
- Impact on LOS IPPV and mortality
- ...positive, without stat sig. (Fartoukh et al: Chest 2002, Adenigbagbe A: Chest 2007)
- ...larger effusion with larger benefit (Talmor et al: Surgery 1998)
- Quantification, therapeutic tap: >350-400 ml
- Time factor (PH, cardiac failure..)



# Distribution of pleural fluid: bi-conical shape, common base



Remerand, et al: Intensive Care Med 2010  
 $V [ml] = Area [cm^2] \times Length [cm]$

CORRESPONDENCE

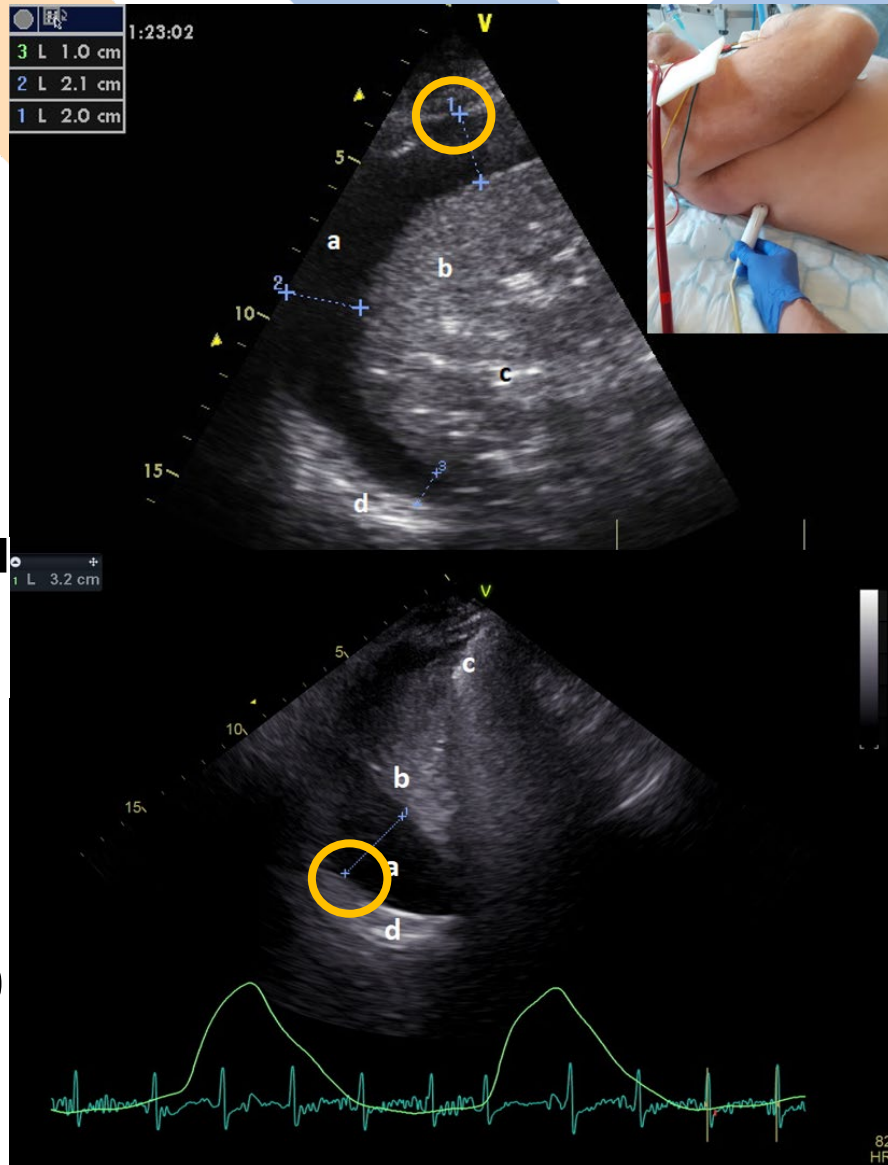
Open Access



Pulmonary consolidation alters the ultrasound estimate of pleural fluid volume when considering chest drainage in patients on ECMO

$$\text{Volume} = L \text{ sep}[\text{mm}] * 17 + 540$$

(prediction error 129 ml)



Intensive Care Med (2006) 32:318–321  
DOI 10.1007/s00134-005-0024-2

BRIEF REPORT

M Balik  
P Plasil  
P Waldauf

Ultrasound estimation of volume of pleural fluid in mechanically ventilated patients

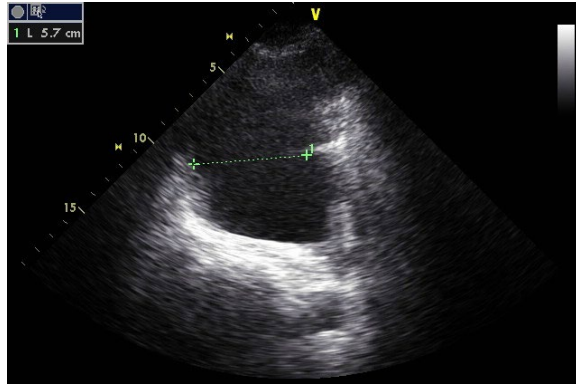
The Use of Point-of-Care Bedside Lung Ultrasound Significantly Reduces the Number of Radiographs and Computed Tomography Scans in Critically Ill Patients

Adriano Peris, MD,\* Lorenzo Tutino, MD,\* Giovanni Zagli, MD,\* Stefano Batacchi, MD,\* Giovanni Cianchi, MD,\* Rosario Spina, MD,\* Manuela Bonizzoli, MD,\* Luisa Migliaccio, MD,\* Lucia Perretta, MD,\* Marco Bartolini, MD,† Kevin Ban, MD,† and Martin Balik, MD, PhD§  
(Anesth Analg 2010;111:687–92)

$$\text{Volume} = \text{separation} [\text{mm}] * 20$$

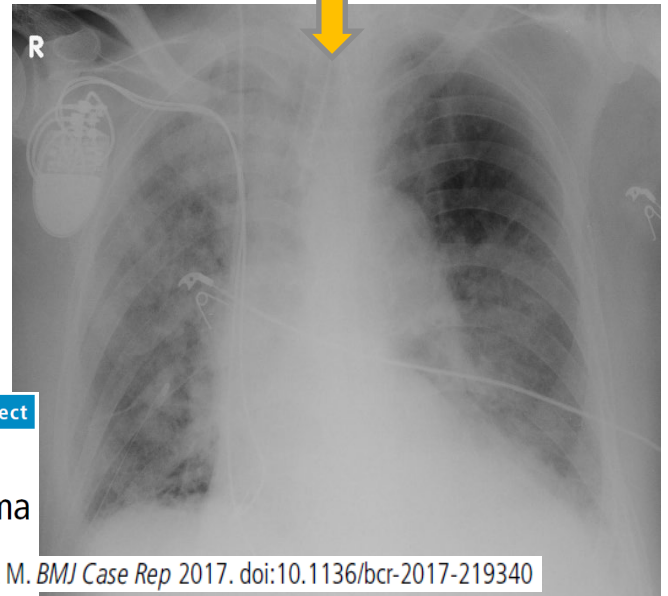
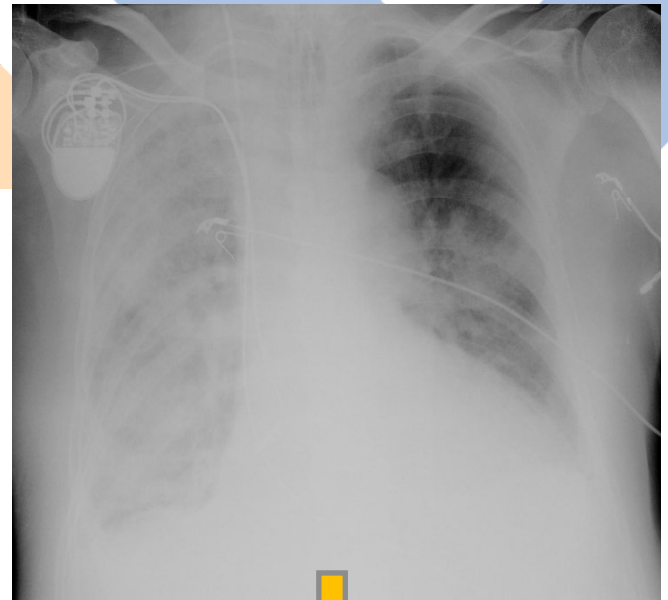
(prediction error 150 ml)

# What is the LVEDP pre-drainage of large enough fluidothorax ?



LVEDP 26 mmHg on TTE: 800 ml of transudate evacuated without neg. pressure....

...resulting in pulmonary edema with a need for rising PEEP,  $\text{FiO}_2$  and addition of Dobutamine 5.0 ug/kg.min



Findings that shed new light on the possible pathogenesis of a disease or an adverse effect



CASE REPORT

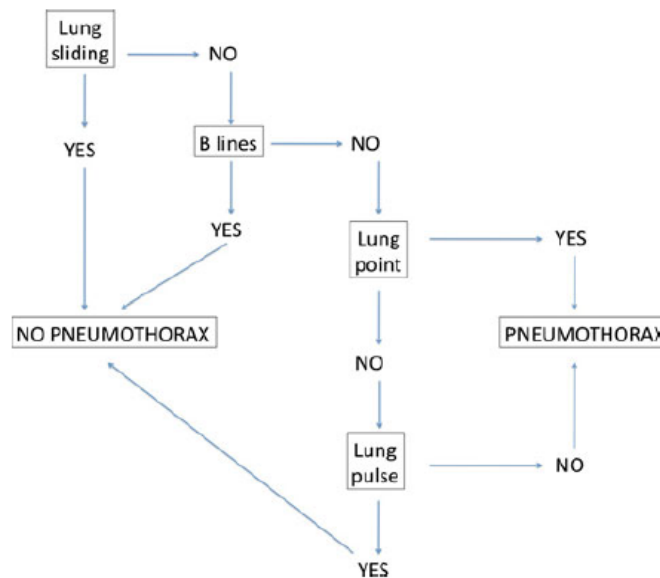
Is the mechanism of re-expansion pulmonary oedema in a heart-lung interaction?

Candy Masego Mokotedi, Martin Balik

Mokotedi CM, Balik M. *BMJ Case Rep* 2017. doi:10.1136/bcr-2017-219340

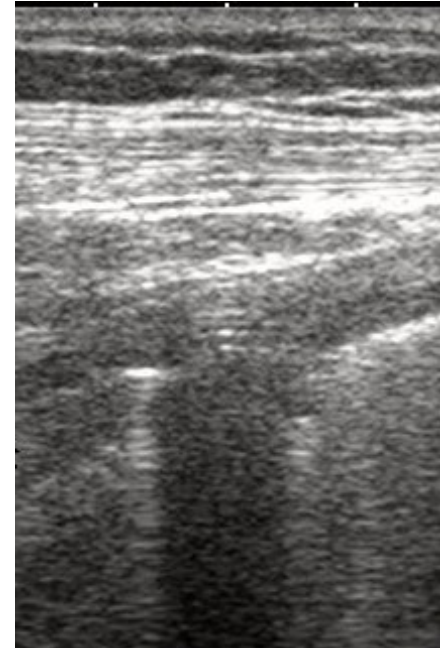
Giovanni Volpicelli  
Mahmoud Elbarbary  
Michael Blaivas  
Daniel A. Lichtenstein  
Gebhard Mathis  
Andrew W. Kirkpatrick

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



# CUS a drenáž: Poloha hrudního drenu jako 5. příznak vylučující pneumothorax ?

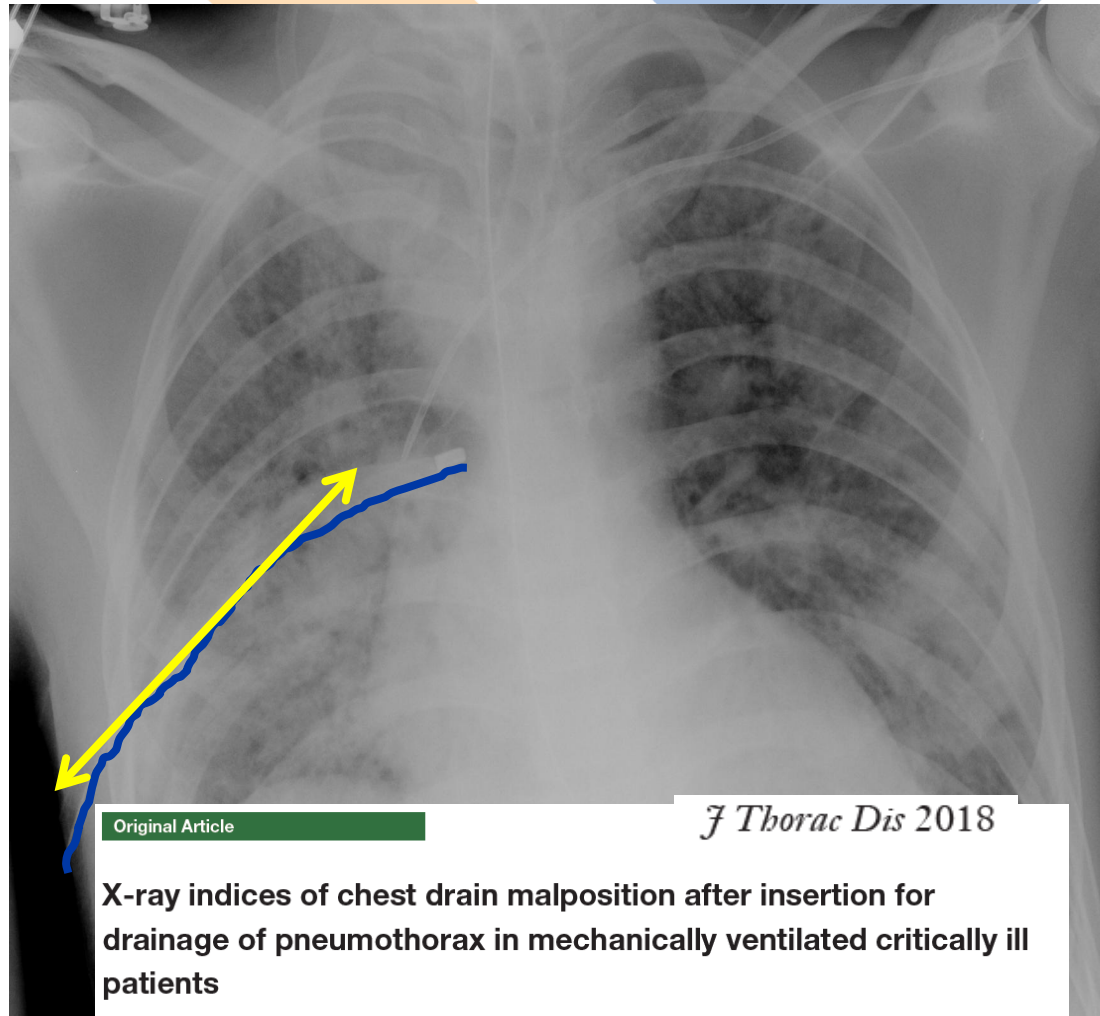
- Význam ventroapikálně – omezený sliding
- Malpozice HD až 30% (Remerand F, Anesthesiology 2007)
- Riziko okultního ventrálního PNO ! .....



Malý M, et al: Interpleural location of chest drain on ultrasound excludes pneumothorax and associates with a low degree of chest drain foreshortening on the anteroposterior chest X-ray, under review 2022

# Kontrola polohy drenu a drenáže: RTG a CUS

- U drenáže PNO: „vlaštovkovité zalomení“ v místě přitištění drenu plicí pod hrudní stěnu.
- Cm na drenu by měly odpovídat průběhu v AP projekci (10cm = 10 cm + 5 cm)
- Tortuosita HD zvýšená: ventrálně nebo dorsálně zavedený dren v AP postavení – v plíci !!!



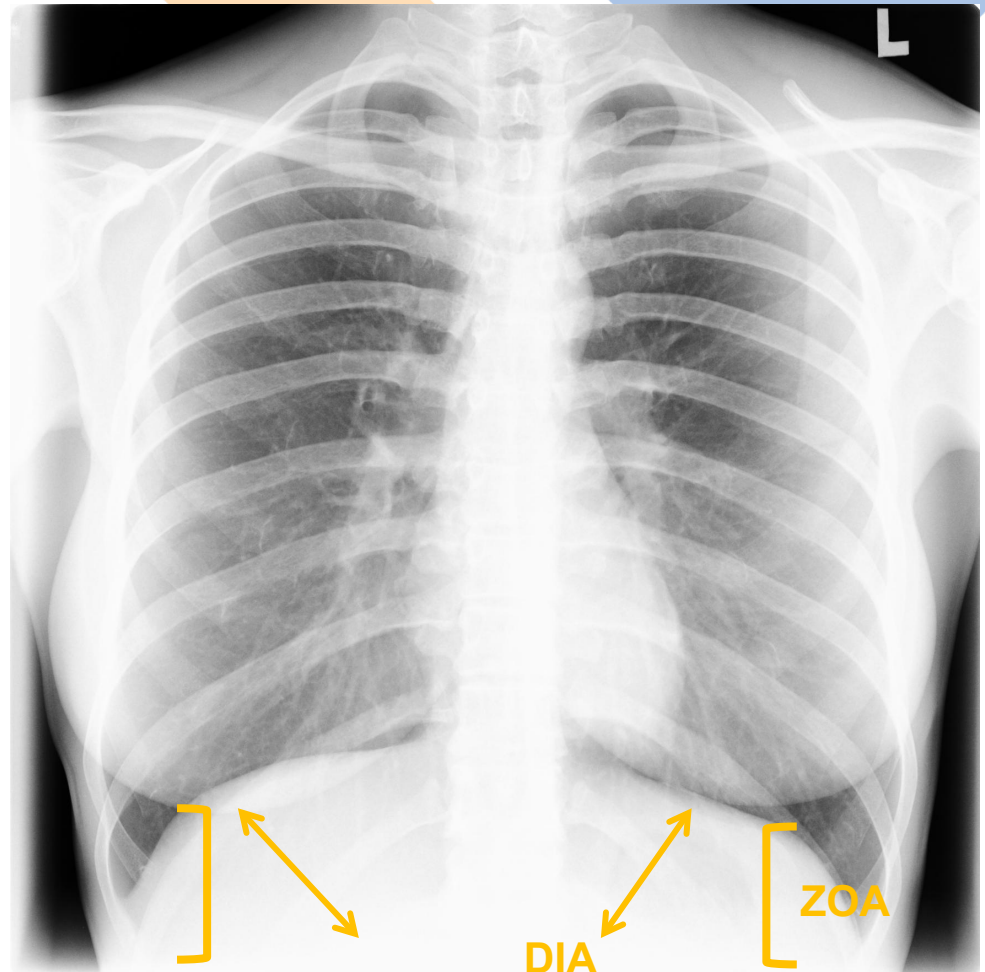
Masego Candy Mokotedi<sup>1</sup>, Lukas Lambert<sup>2</sup>, Lucie Simakova<sup>2</sup>, Michal Lips<sup>1</sup>, Michal Zakharchenko<sup>1</sup>, Jan Rulisek<sup>1</sup>, Martin Balik<sup>1</sup>

# Weaning: diaphragm as major respiratory muscle

Zone of apposition  
(ZOA): caudal  
movement

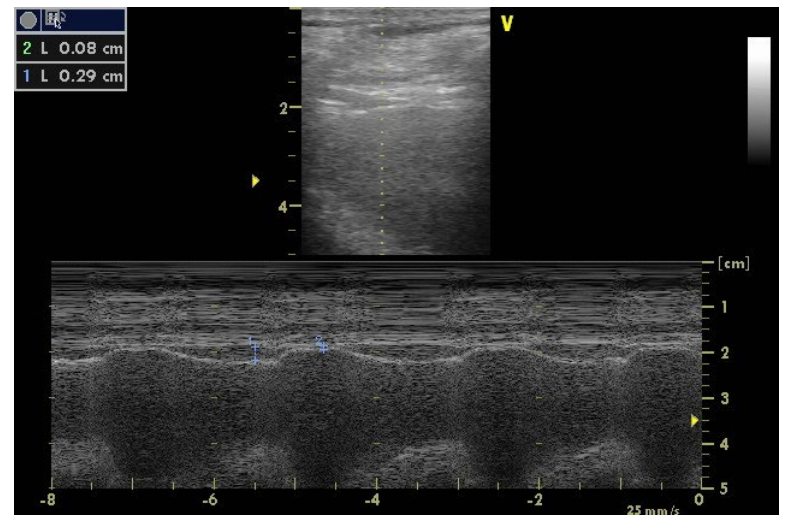
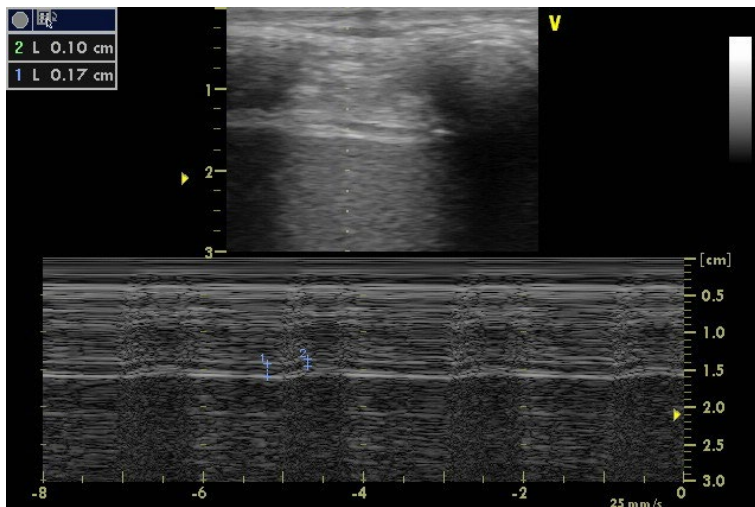
chest wall  
ventral and  
lateral

Diaphragmatic  
amplitude (DIA)

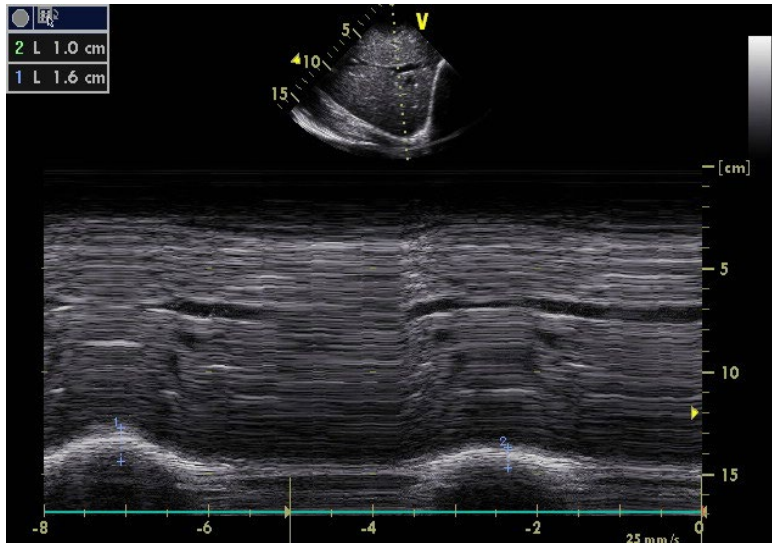




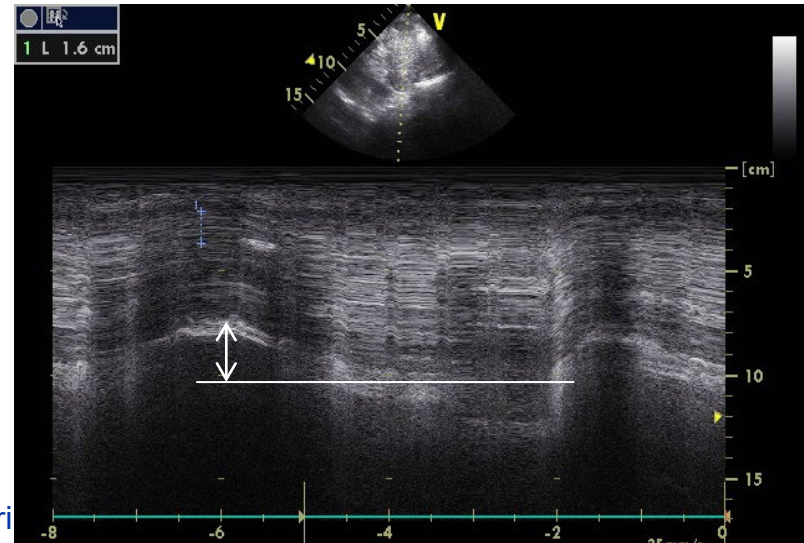
# ZOA: Zlúšťování bránice (TF min 20-25%)



# Diafragmatická amplituda: DIA min 1.0-1.5 cm



1.LF UK A VFN V PRAZE

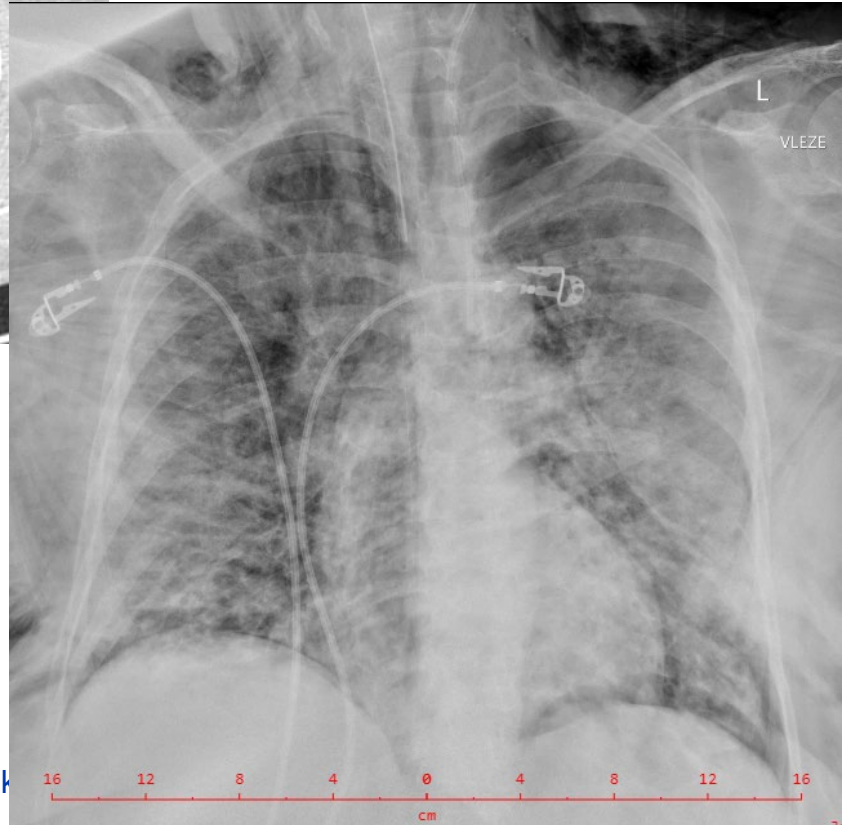


# DIA: Pareza bránice (AMM)

# Airway: CUS před tracheostomií

- Infra or supraisthmic dissection expected ?
- Depth of trachea from not compressed skin: Portex or Rusch/Mallincrodt ?
- Size of trachea ?
- ET pulled out under US control
- Vessel structures ?
- Infectious issues – elimination of soiling from trachea

# Limitace CUS





VŠEOBECNÁ FAKULTNÍ  
NEMOCNICE V PRAZE



1. LÉKAŘSKÁ  
FAKULTA  
Univerzita Karlova

**KARIM**

**KLINIKA  
ANESTEZIOLOGIE,  
RESUSCITACE A  
INTENZIVNÍ MEDICÍNY**

U Nemocnice 499/2, 128 08 Praha 2  
Tel.: 224 961 111, [www.vfn.cz](http://www.vfn.cz)

Vážená paní, vážený pane,  
dovolujeme si Vás pozvat na již:

## **XVII. Workshop bronchoskopie v anesteziologii a intenzivní péči,**

který pořádají KARIM a Centrum plicní endoskopie VFN a 1.LF UK  
a Společnost pro anesteziologii, resuscitaci a intenzivní medicínu  
pod záštitou České společnosti intenzivní medicíny (ČSIM)

Akce proběhne **16.12. 2022**

Program workshopu, možnost přihlášení a další  
podrobnosti naleznete na [www.karim-vfn.cz](http://www.karim-vfn.cz)



ČESKÁ SPOLEČNOST  
INTENZIVNÍ MEDICÍNY

 **KARIM**  
1.LF UK A VFN V PRAZE



# Děkuji za pozornost !

Komplexní kardiovaskulární centrum  
KARIM VFN a 1.LF UK

U nemocnice 2; 128 08 Praha 2  
T: +420 224 963 366  
F: +420 224 967 125  
[martin.balik@vfn.cz](mailto:martin.balik@vfn.cz)  
[www.karim-vfn.cz](http://www.karim-vfn.cz)

