

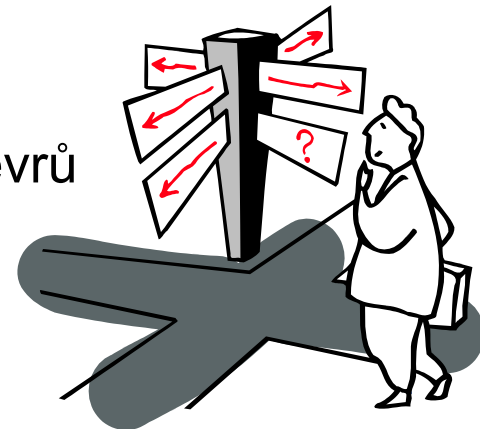
UZ srdce a plic při optimalizaci nastavení ventilátoru

Martin Balík

KARIM 1.LF UK a VFN

Co mi říká echokardiografie a hrudní sono ?

- LV dysfunkce a stanovení LVEDP/LAP, diagnostika MV
 - Diferenciální diagnostika ARDS vs. kardiogenní edém
- RV dysfunkce a stanovení PH
- Preload
- Patologie pleury a plicního parenchymu
- Ventilační strategie
- Zvolení polohy pacienta, pronace, semipronace
- Indikace k bronchoskopii
- Indikace a kontraindikace recruitment manévrů
- Detekce intrakardiálních zkratů



Hemodynamika a respir. selhání

PREDICTORS OF DEATH & PROLONGED VENTILATION - N = 330

Characteristic	Alive and not ventilator-dependent by day 15	Dead, ventilator-dependent, or with tracheostomy by day 15	P
Day 3 PaCO ₂ (mmHg)	39 (33 to 44)	41 (36 to 47)	0.012
Day 3 PaO ₂ /FiO ₂	174 (146 to 195)	153 (105 to 198)	0.013
Day 3 PEEP (cmH ₂ O)	5 (5 to 9)	8 (5 to 12)	0.003
Day 3 oxygenation index	10.4 (8.2 to 14.7)	13.9 (9.3 to 23.1)	0.001
Day 3 SOFA score	9 (7 to 10)	10 (7 to 13)	0.055
Day 3 shock (n [%])	14 (19)	99 (39)	0.001

2nd International Study of Mech Ventilation and ARDS-net Investigators. CRIT CARE 2007

Respiratory	60 (96.9)	387 (95.3)
Cardiovascular	24 (38.7)	222 (55.4)
Neurological	28 (43.2)	142 (35.4)
Renal	41 (66.1)	300 (74.8)
Liver	7 (11.3)	67 (16.7)
Haematological	5 (8.1)	75 (18.7)
Severe sepsis/shock	6 (9.7)	91 (22.7)
Arterial blood pH, mean (SD)	7.40 (0.10)	7.34 (0.14)
PCO ₂ , mean (SD)	39.7 (9.5)	44.9 (12.7)
PaO ₂ /FiO ₂ ratio (day 0), mean (SD)	239 (30)	119 (43)
SAPS II on admission, median (IQR)	34 (24-45)	41 (32-52)
LOD score at inclusion, mean (SD)	4.9 (2.5)	7.1 (3.5)

Brun-Buisson C, et al. ALIVE Study. INT CARE MED 2003

Diagnostika zvýšeného LVEDP a LAP

THE BERLIN DEFINITION OF ACUTE RESPIRATORY DISTRESS SYNDROME

Table 1. The AECC Definition³—Limitations and Methods to Address These in the Berlin Definition

	AECC Definition	AECC Limitations	Addressed in Berlin Definition
Timing	Acute onset	No definition of acute ^c	Acute time frame specified
ALI category	All patients with $\text{PaO}_2/\text{FiO}_2 < 300$ mm Hg	Misinterpreted as $\text{PaO}_2/\text{FiO}_2 = 201\text{--}300$, leading to confusing ALI/ARDS term	3 Mutually exclusive subgroups of ARDS by severity ALI term removed
Oxygenation	$\text{PaO}_2/\text{FiO}_2 \leq 300$ mm Hg (regardless of PEEP)	Inconsistency of $\text{PaO}_2/\text{FiO}_2$ ratio due to the effect of PEEP and/or FiO_2 ⁵⁻⁷	Minimal PEEP level added across subgroups FiO_2 effect less relevant in severe ARDS group
Chest radiograph	Bilateral infiltrates observed on frontal chest radiograph	Poor interobserver reliability of chest radiograph interpretation ^{8,9}	Chest radiograph criteria clarified Example radiographs created ^a
PAWP	PAWP ≤ 18 mm Hg when measured or no clinical evidence of left atrial hypertension	High PAWP and ARDS may coexist ^{10,11} Poor interobserver reliability of PAWP and clinical assessments of left atrial hypertension ¹²	PAWP requirement removed Hydrostatic edema not the primary cause of respiratory failure Clinical vignettes created ^a to help exclude hydrostatic edema
Risk factor	None	Not formally included in definition ⁴	Included When none identified, need to objectively rule out hydrostatic edema

Abbreviations: AECC, American-European Consensus Conference; ALI, acute lung injury; ARDS, acute respiratory distress syndrome; FiO_2 , fraction of inspired oxygen; PaO_2 , arterial partial pressure of oxygen; PAWP, pulmonary artery wedge pressure; PEEP, positive end-expiratory pressure.

^aAvailable on request.

ALI

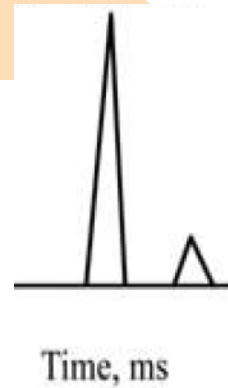
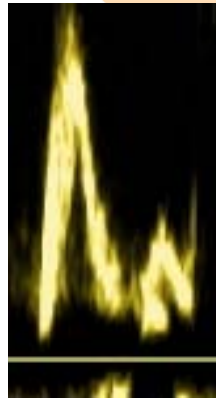
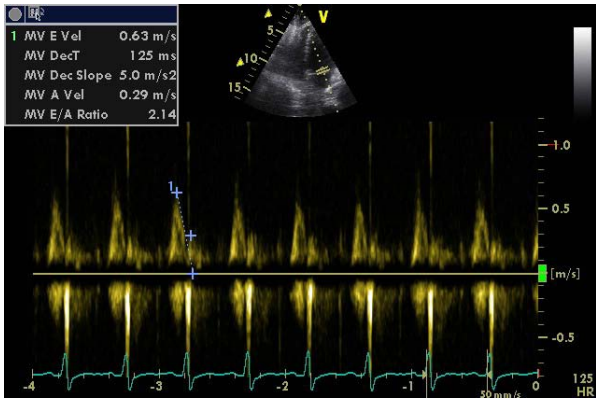
- Bilat infiltráty
- Hypoxemie - $\text{P}_a\text{O}_2/\text{F}_i\text{O}_2 < 300$
- PCWP < 18 mmHg (není evidence zvýš.LAP)

ARDS

- Hypoxemie - $\text{P}_a\text{O}_2/\text{F}_i\text{O}_2 < 200$ torr

(Cons.conf.1994)

LVEDP a LAP

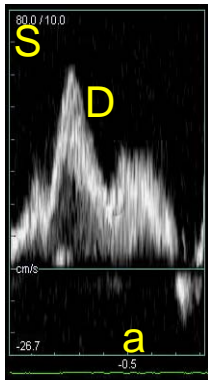


Transmitrální doppler a 100 % PPV pro PAWP >18 mmHg (Boussugues A, et al: Crit Care Med 2002, Giannuzzi P, J Am Coll Cardiol 1994)

Pulm Veins PW Systolic Fraction (SF) =

$$\frac{S \text{ VTI}}{S \text{ VTI} + D \text{ VTI}}$$

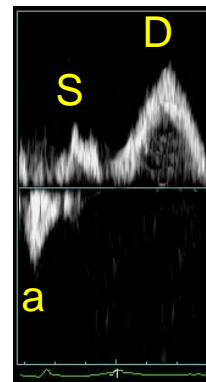
Vargas F: Pulmonary venous flow. J Crit Care 2004



SF > 55%

PAOP < 15 mm Hg

PPV 100% (95% CI, 63-100%)

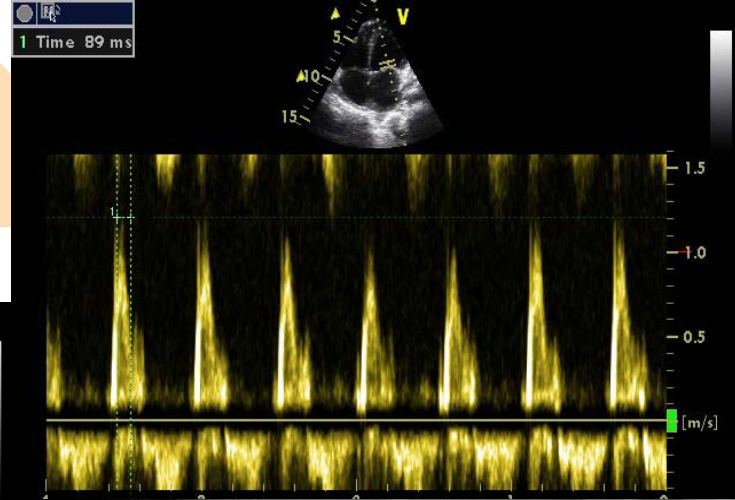
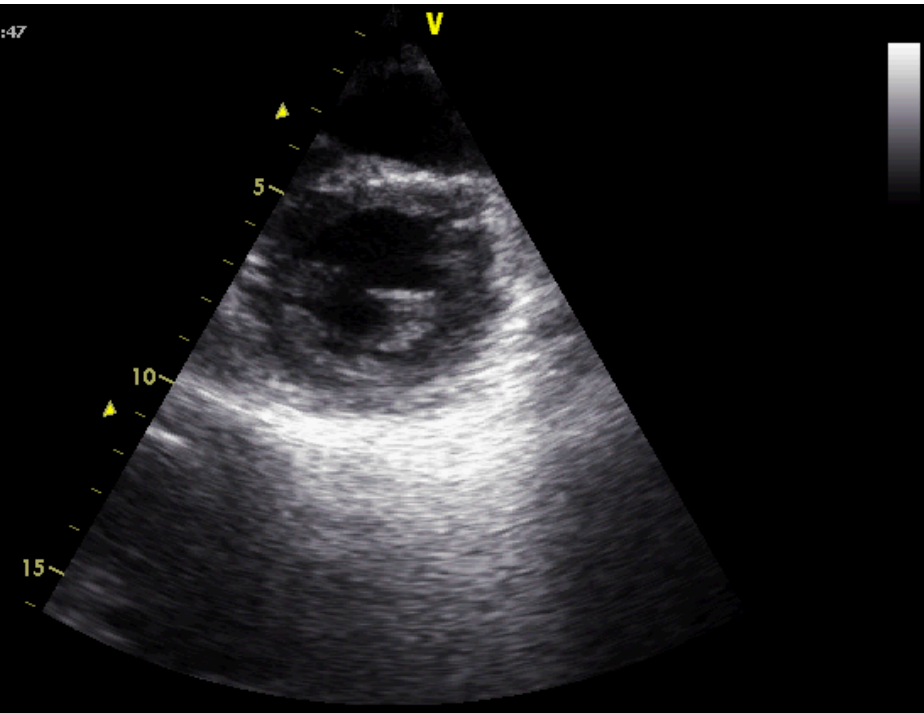


SF < 40%

PAOP >18 mm Hg

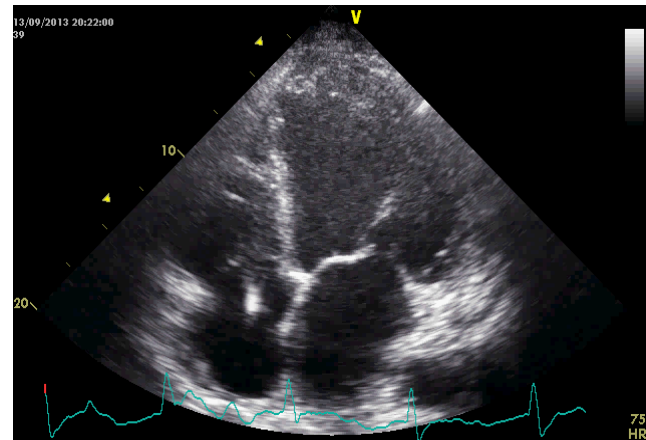
PPV 100% (95% CI, 52-100%)

Je to opravdu ARDS ? Jaký je LVEDP ?



Hemodynamická indikace k IPPV a PEEP: U snížené systolické funkce LK

- Vzestup RVEDV a pokles LVEDV (preload) (Pinsky MR: Intensive Care Med 1997)
- Pokles transmurálního ΔP (Pinsky MR: J Appl Physiol 1993) snižuje LVESV (ESA, afterload)
- Vzestup SV (Naughton MT: Circulation 1995)
 - reverzní pulsus paradoxus
 - dUp effect
(Pp, BPs variation)



IPPV a PK

Vt je determinantou vzestupu PVR (Vieillard-Baron A: J Appl Physiol 1999, Poelaert J: J Cardiothorac Vasc Anesth 1994)

1.) Špatně nastavená IPPV může přispět k:

- poklesu RVEF
- vzestupu RVEDV a dilataci RV

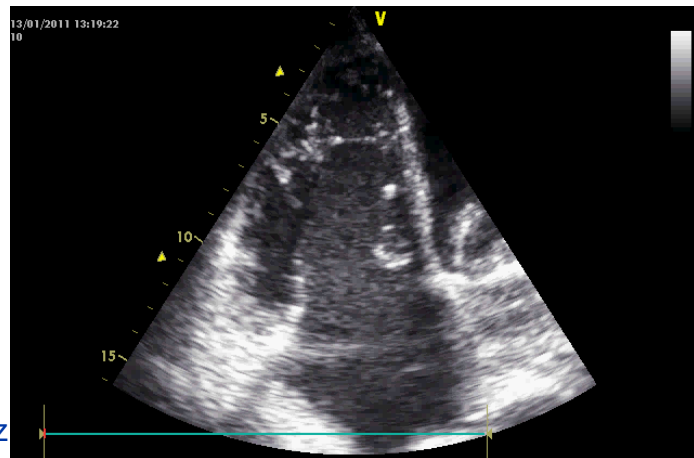
2.) Permanentní vzestup PVR vede k akutnímu cor pulmonale:

- a.) RV dilatace ($RVEDA/LVEDA > 0.6$)
- b.) paradoxní pohyb septa

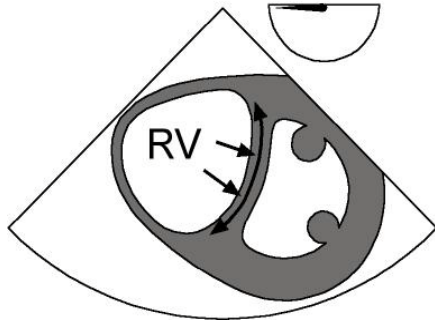
4.) Vzestup CVP snižuje syst. preload

5.) Pokles SV and CO

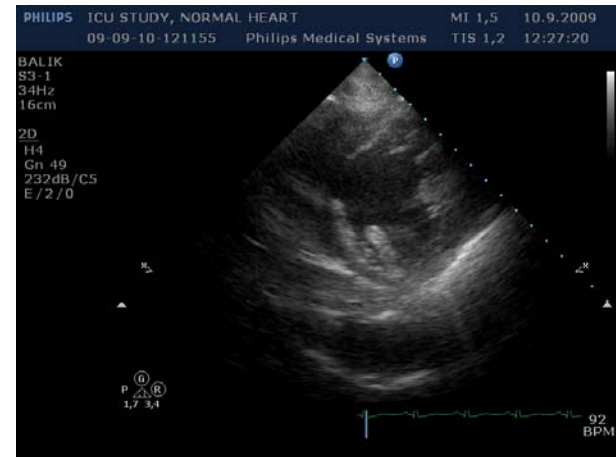
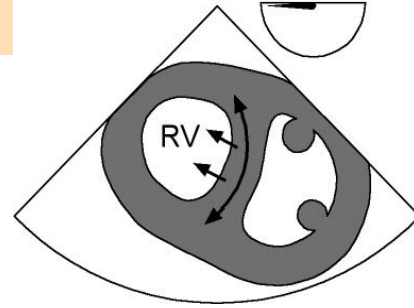
- pulsus paradoxus
- dDown effect (Pp, BPs variation)



ACP Diastole

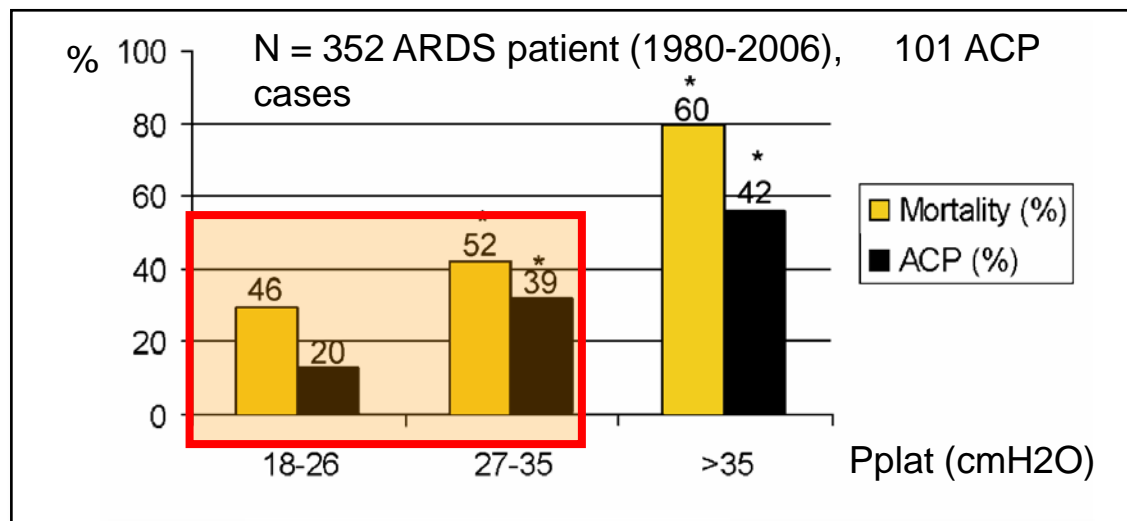


CCP Systole



Dysfunkce PK na UPV

- ARDS: ACP až 33% (Jardin F, Intensive Care Med 2007)
- Při Pplat do 27 mbar jen 13%
- Přežití na IPPV je lineárně související s EFPK (Steltzer H, et al: Anaesthesia 1994)



N = 352 ARDS patient (1980-2006), 101 ACP cases

ACP 13%
for Pplat < 27
cmH2O

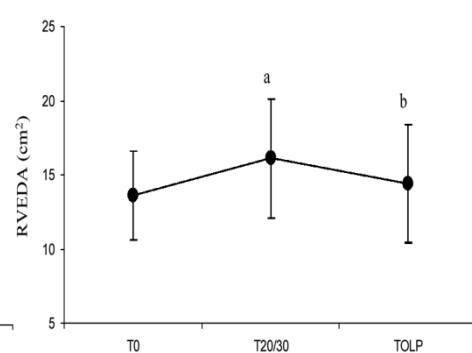
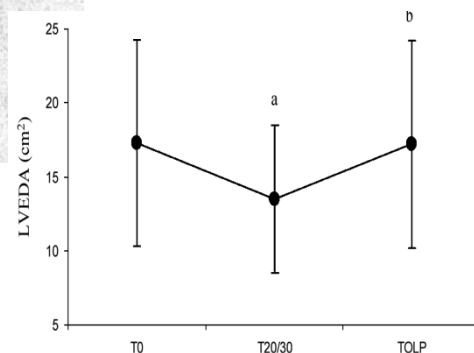
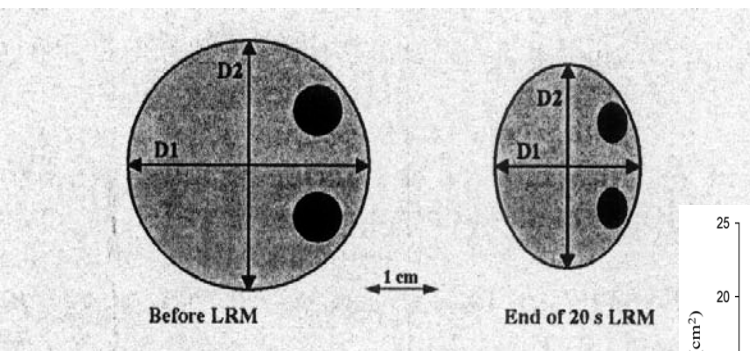
Jardin F, Vieillard-Baron A. INT CARE MED 2007

www.karim-vfn.cz

Ubližování PK na UPV: Recruitment manévr

Pokles EI ($D2/D1$) = RV tlakové přetížení, riziko ACP

Pokles SV_{RV} a LV preload redukuje SV a CO o 50% a MAP o 20% (Nielsen J: Intensive Care Med 2005)



Critical Care 2009, **13**:R59 (doi:10.1186/cc7786)

Research

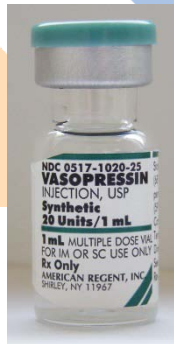
Respiratory and haemodynamic changes during decremental open lung positive end-expiratory pressure titration in patients with acute respiratory distress syndrome

Christian Gernoth¹, Gerhard Wagner², Paolo Pelosi³ and Thomas Luecke¹

Open Access

Ochrana PK na UPV

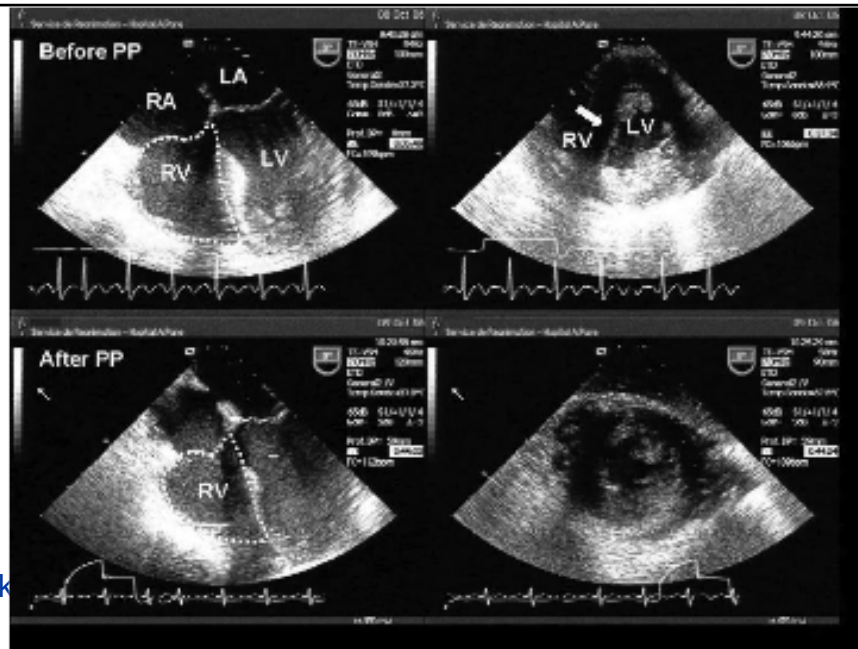
- Limitace Pplat pod 27-30 mbar, Vt max 8 ml/kg
- Režimy se spont. aktivitou
- Evakuace sig. pleur výpotků: Snížení TPP a Pplat
- FOB eliminace atelektáz
- I/E, RR a Vt: Minimalizace airtrapping
- Pronační poloha časně (>60% FiO₂)
- Cave preload a ACP/CCP !
- Vasopressin a redukce NAD
- Nebulizace PGI₂ nebo NO



Prone Positioning Unloads the Right Ventricle in Severe ARDS

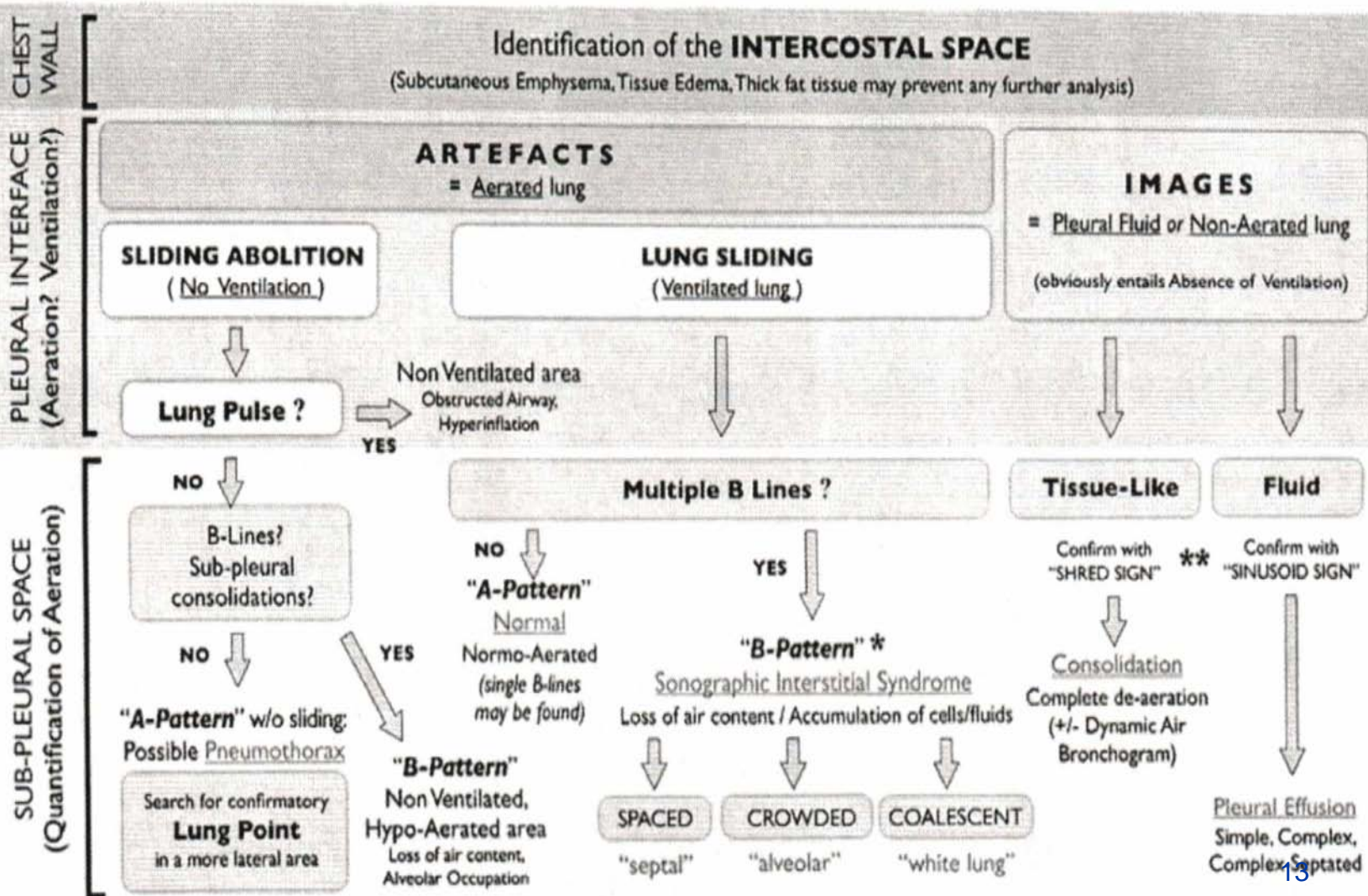
Antoine Vieillard-Baron, Cyril Charron, Vincent Calle, Guillaume Belliard, Bernard Page and François Jardin

Chest 2007;132;1440-1446; Prepublished online October 9, 2007; DOI 10.1378/chest.07-1013




Sekvenční interpretace hrudního UZ


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



Systematický přístup v hrudním UZ navazující na echoprotokol: 12 zón



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

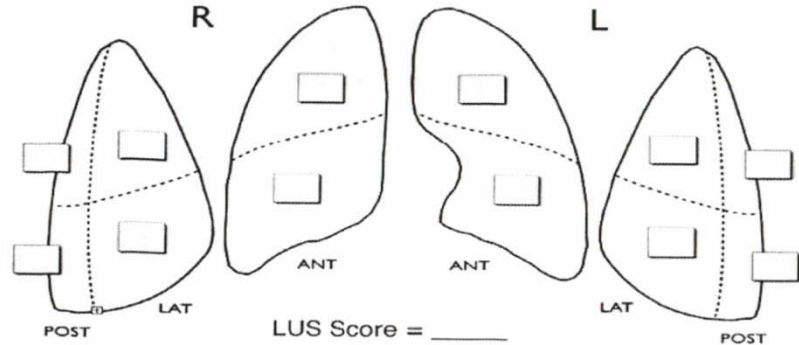
MECH VENTILATION: a) Modality: PCV DuoPAP ASV PSV SIMV NIV CPAP

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

.....

.....

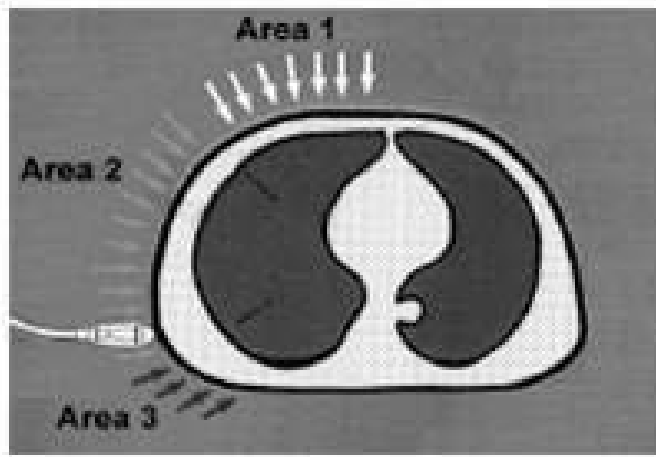
DIAGNOSIS

Suspected Not made Second Opinion needed

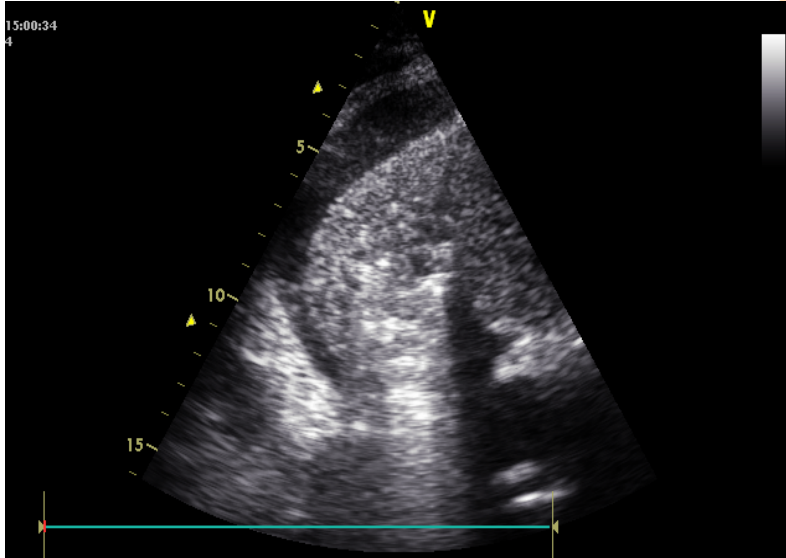
----- Signature

Pravá:
 Horní: Ant – Lat – Post
 Dolní: Ant – Lat – Post
 Levá:
 Horní: Ant – Lat – Post
 Dolní: Ant – Lat – Post

(Via G, et al: Minerva Anesthesiol 2012)

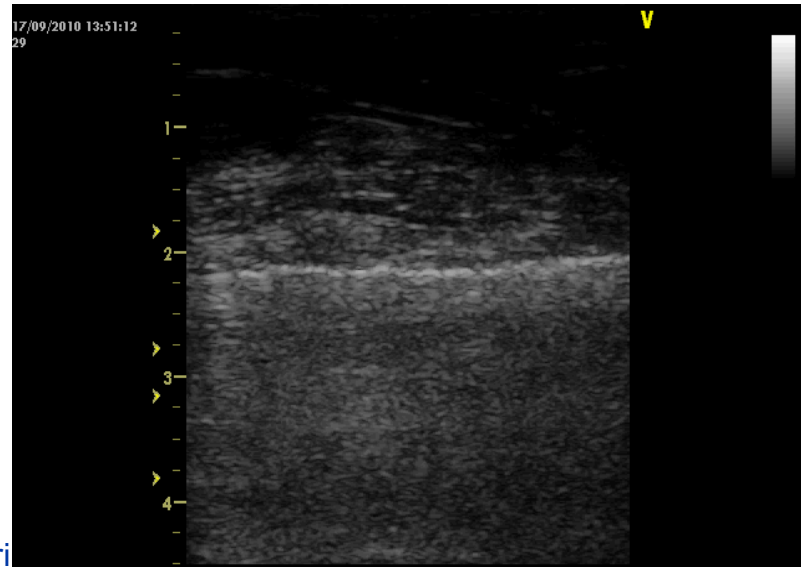


Fluidothorax a pneumothorax: Snížení P_{pleur} snižuje TPP a P_{plat} potřebný k recruitment plic. parenchymu



- Kvantifikace

- Terapeutická punkce: obvykle nad 350-400 ml
- Diagnostická punkce
- Volume = separation [mm] * 20 (prediction error 150 ml)

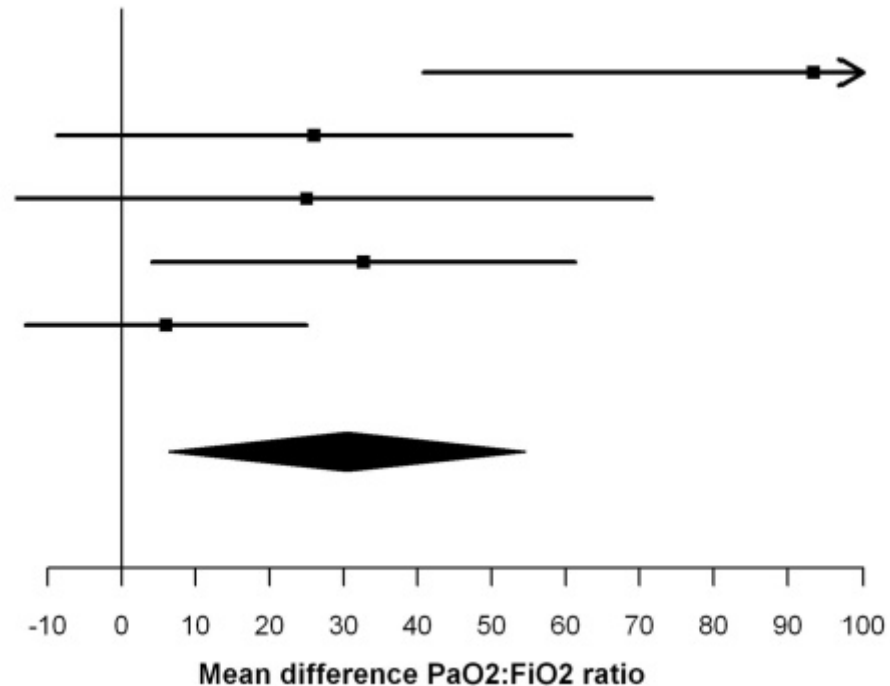


Balik M, et al: Intensive Care Med 2006

Peris A, Balik M, et al: Anaesth Analg 2010

Příznivý dopad drenáže na oxygenaci a dobu IPPV

- 19 studií v metaanalýze
- Vzestup $\text{paO}_2/\text{FiO}_2$ o 18% po drenáži
- Goligher et al: Crit Care 2011
- Dopad na dobu UPV, LOS a mortalitu
- Pozitivní, ale bez stat signifikance (Fartoukh et al: Chest 2002, Adenigbagbe A: Chest 2007)
- Čím větší objem, tím větší benefit (Talmor et al: Surgery 1998)



Vzestup $\text{paO}_2/\text{FiO}_2$ o 30

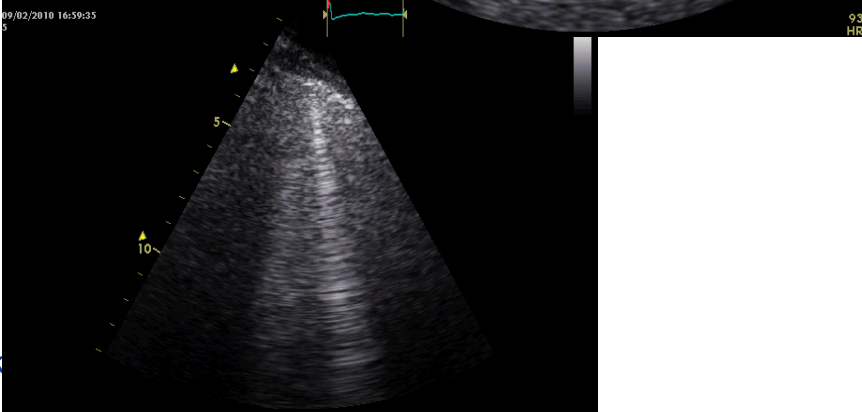
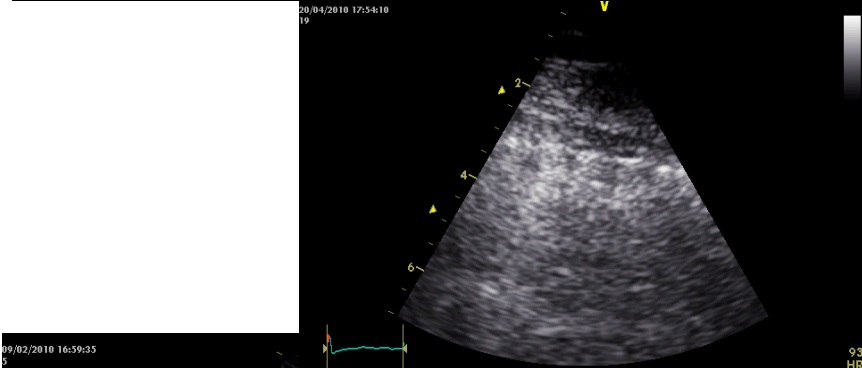
Detekce pleury, puls, sliding, A a B linie

A linie: reverberace pleurální linie

B linie: Interlobulární septa akumulují tekutinu, 25-28% nad bránicí na UPV

- ALI, ARDS
- kard. pl. edém
- pneumonie
- chronic interst. proces

Předcházejí X-ray u edému (Badgett RG 1996, Lichtenstein 2005, 2007)

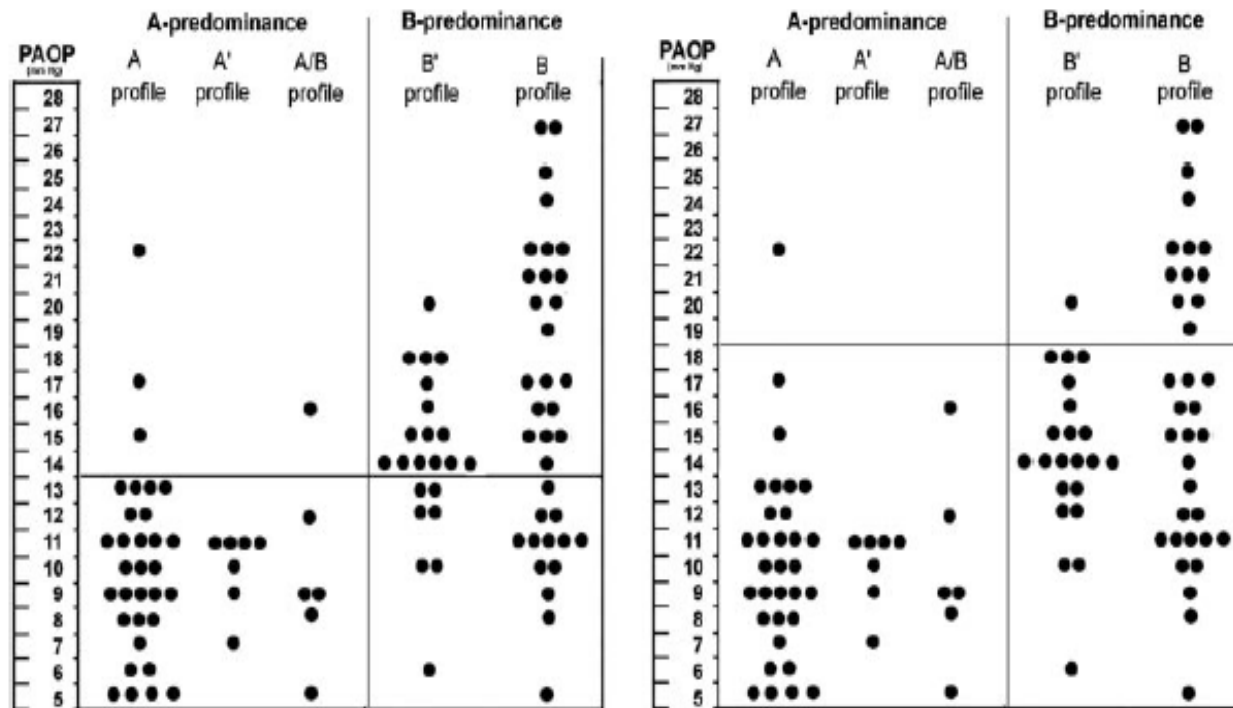


Odhad preload: A vs B linie

PAOP < 13 mm Hg: A-predominance 90% specif., 67% sens.

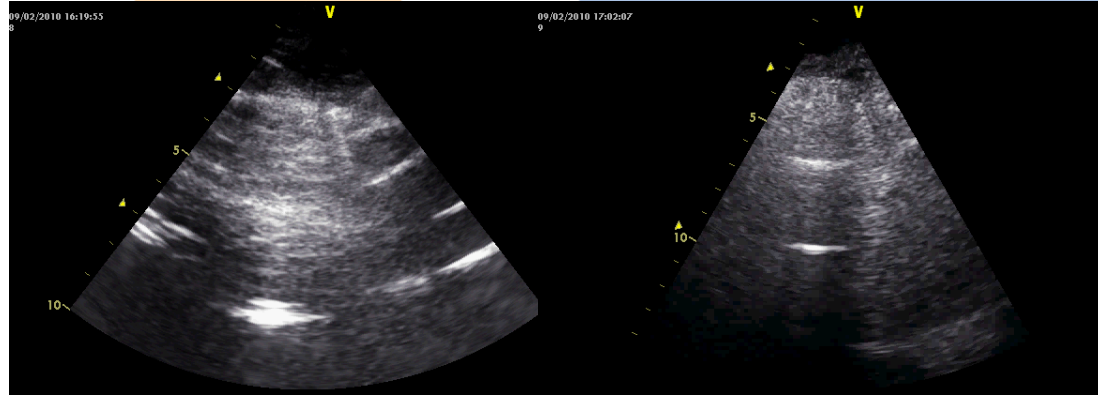
PAOP < 18 mmHg: A-predominance 93% specif., 50% sens.

A-predominance: tekutinová výzva bez inic. rizika pl. edému

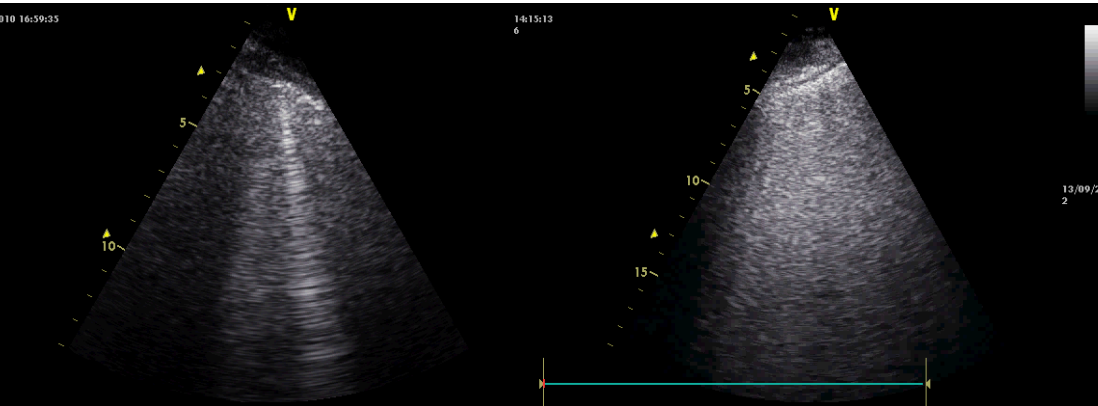


4 stupně konsolidace plicního parenchymu dle UZ

I (**N**) – A linie, vzdušná plíce, oj. kometa, Z linie přípustné

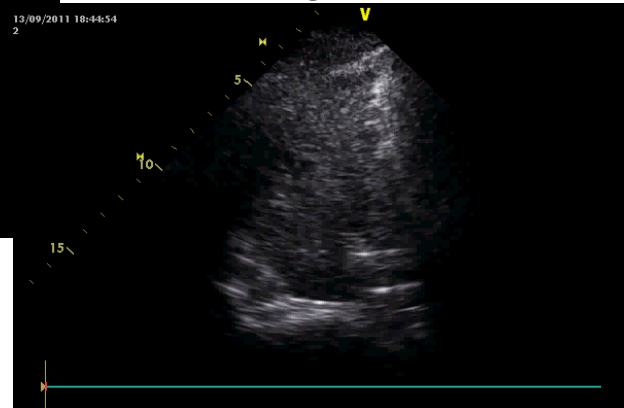


II (**B1**) - B linie, do B4-7 mm, A linie není patrna



III (**B2**) – B linie 3 mm až splývající

IV (**C**) - Konsolidace, dynamický bronchogram, diff dg. atelektáza se statickým (fluidním) bronchogramem



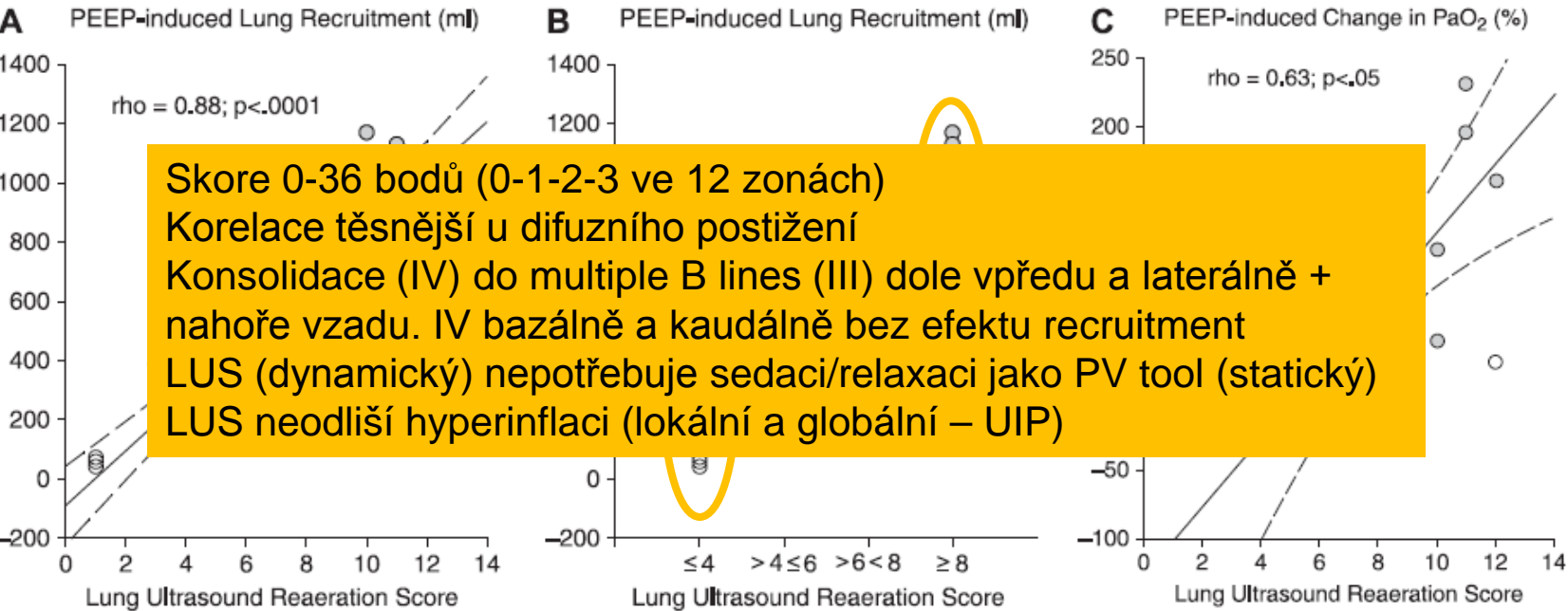
Bedside Ultrasound Assessment of Positive End-Expiratory Pressure–induced Lung Recruitment

Belaïd Bouhemad¹, H el ene Brisson¹, Morgan Le-Guen¹, Charlotte Arbelot¹, Qin Lu¹, and Jean-Jacques Rouby¹

Quantification of reaeration*			Quantification of loss of aeration		
1 point	3 points	5 points	5 points	3 points	1 point
B1 → N	B2 → N	C → N	N → C	N → B2	N → B1
B2 → B1	C → B1			B1 → C	B1 → 2
C → B2					B2 → C

Definition of abbreviations: B1 = multiple well-defined either regularly spaced 7-mm apart or irregularly spaced B lines (moderate loss of lung aeration); B2 = multiple coalescent B lines (severe loss of lung aeration); C = lung consolidation; N = normal pattern (normal lung aeration).

US reaeration score (40 pts ARDS,ALI):
US a PV curves
PEEP 015
(AJRCCM 2011)



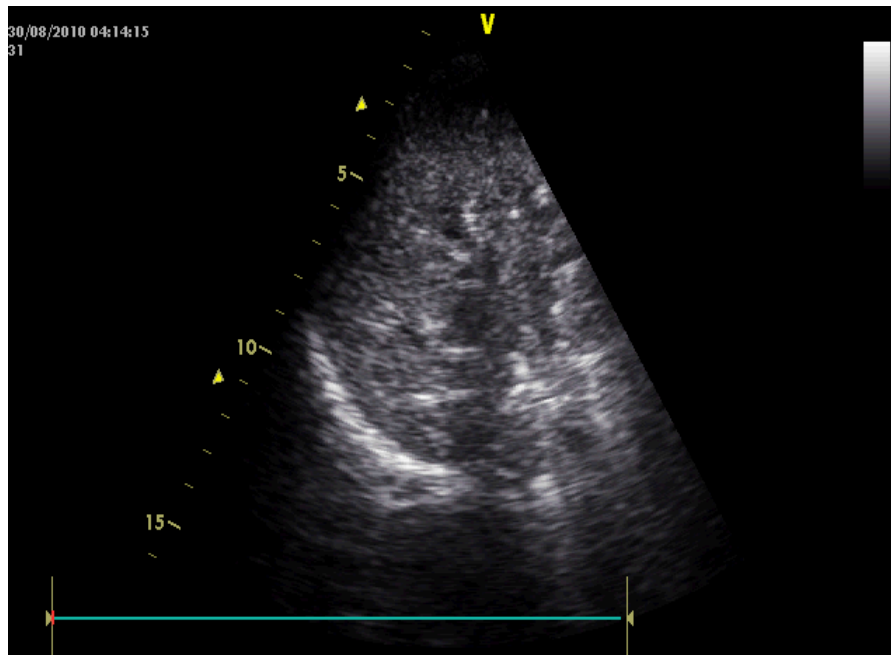
Skore 0-36 bod u (0-1-2-3 ve 12 zon ach)
Korelace t esn ej s i u difuzn iho po st i en i
Konsolidace (IV) do multiple B lines (III) dole vp redu a later aln e + naho re vzadu. IV baz aln e a kaud aln e bez efektu recruitment
LUS (dynamick y) nepot rebuje sedaci/relaxaci jako PV tool (statick y)
LUS neodli s i hyperinflaci (lok aln i a glob aln i – UIP)

Lung recruitment score a jeho využití

- **ARDS: Rozhodnutí o LRM, korelace (nespec.) s EVLW** (Baldi G: Intensive Care Med 2013)
- Homogenita parenchymu: Difuzní postižení s efektem (Constantin 2010)
- Stupeň konsolidace: **III do II a nebo I; II do I**; ale **IV do III nebo II vzácně** (lateral, anterior dole, nebo posterior nahoře)
- **Monitoring efektu polohování a pronační polohy** (Tsubo T: Crit Care Med 2004)
- **Monitoring efektu ATB a terapie VAP** (Bouhemad B, Crit Care Med 2010)
- **Predikce selhání SBT** (na konci intervalu na T-tubusu u OTI)
- Derecruitment anterior, laterálně, vzadu posterior (Soummer A, et al: Crit Care Med 2012)
- <13 extubace.....13-17.....>17 postextubační distress a NIV

	Overall 100 Patients	SBT Failure 14 Patients	SBT Success 86 Patients	<i>p</i>	Postextubation Success 57 Patients	Postextubation Distress 29 Patients	<i>p</i>
LUS before SBT	12 [9–15]	13 [10–17]	12 [8–15]	NS	10 [6–13]	15 [13–17]	<.001
LUS end of SBT	13 [9–17] ^a	15 [13–21] ^a	13 [8–17] ^a	.002	10 [7–13]	19 [16–21] ^a	<.001
LUS H4 postextubation	—	—	—	—	10 [7–15]	20 [17–23] ^{b,c}	<.001
BNP before SBT, pg/mL	227[80–590]	180 [75–823]	241 [79–541]	NS	139 [64–316]	475 [232–689]	.003
BNP end-SBT, pg/mL	205 [75–628] ^b	207 [75–1260] ^b	201 [73–518]	NS	137 [65–315]	459 [152–958]	.002
BNP H4 extubation	—	—	212 [82–553]	—	152 [63–301]	465 [166–915]	.001

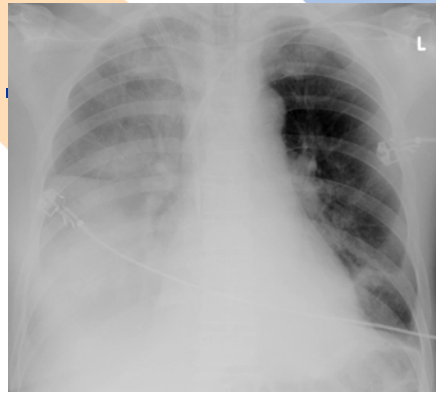
Proč nebudu u tohoto pacienta provádět recruitment manévr ?



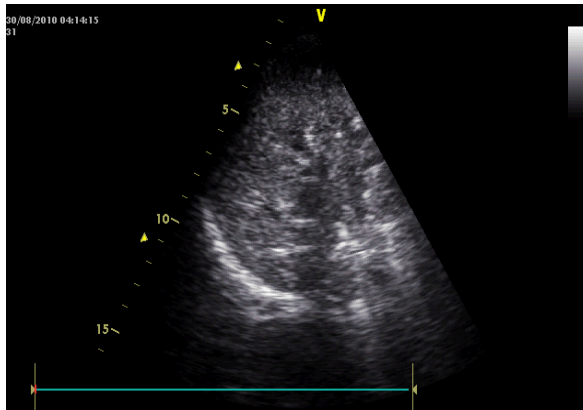
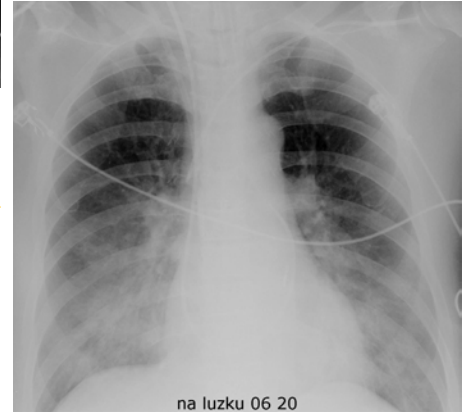
- HAP s aspiračním podílem
- Dynamický bronchogram – po provedení FOB a BAL

O 36h později.....

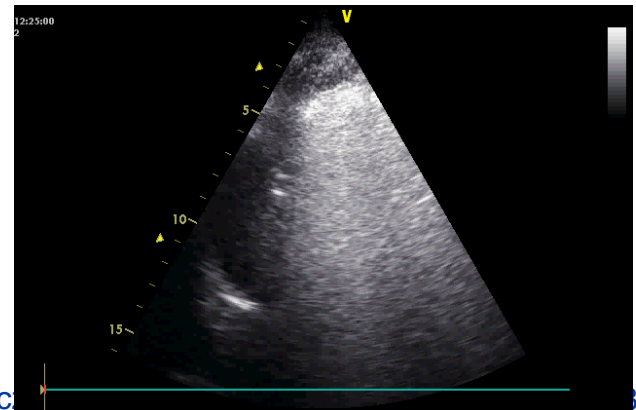
- BIPAP, PEEPext 10 mbar
- L- semipronace, fyzioterapie
- Terapie sept šoku
- Násl. propad EFLK z 44% na 26% s opět vzestupem na 45%
 - septická KMP
- 36h: Na PSV s NAD 0,3 ug/kg.min
- Extubace za dalších 48h



36h



36h



Prevalence and prognosis of shunting across patent foramen ovale during acute respiratory distress syndrome*

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- Prevalence středně a více závažného R-L zkratu je u ARDS 19.2%
- Závažnější poklesy paO_2/FiO_2
- Četnější pronace, aplikace NO
- Delší dobu pobytu na UPV a ICU
- Critical Care Med 2010



Strategie nastavení ventilátoru: TTE a LUS

- Pplat max 27-30 mbar, Vt 6-8 ml/kg, eliminace airtrapping
- Cor pulmonale: Nižší PEEP a vyšší FiO₂ (do 60%)
- Akutní Cor Pulmonale, PH: PaCO₂ < 65mmHg, pH > 7.30
- Preload ve vztahu k pravému srdci, CVP !!! (<15 mmHg)
- Časná pronace, semipronace
- FOB intenzivistou 24/7
- Přísná limitace recruitment manévrů
- Časový faktor: Recruitment (desítky minut) vs postupné otvírání a hojení plic bez hemodyn. kolapsu (desítky hodin)
- Indikované podání iNO, PGI₂



Děkuji za pozornost.

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