Lung Ultrasound in Respiratory Distress Syndrome

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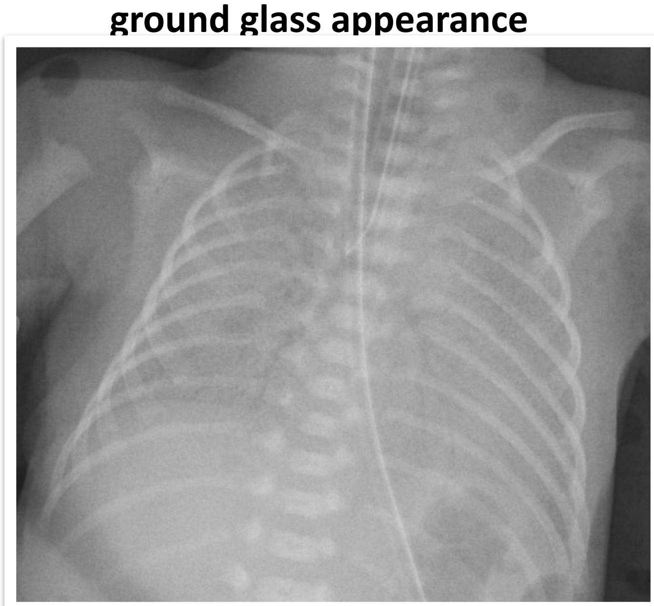
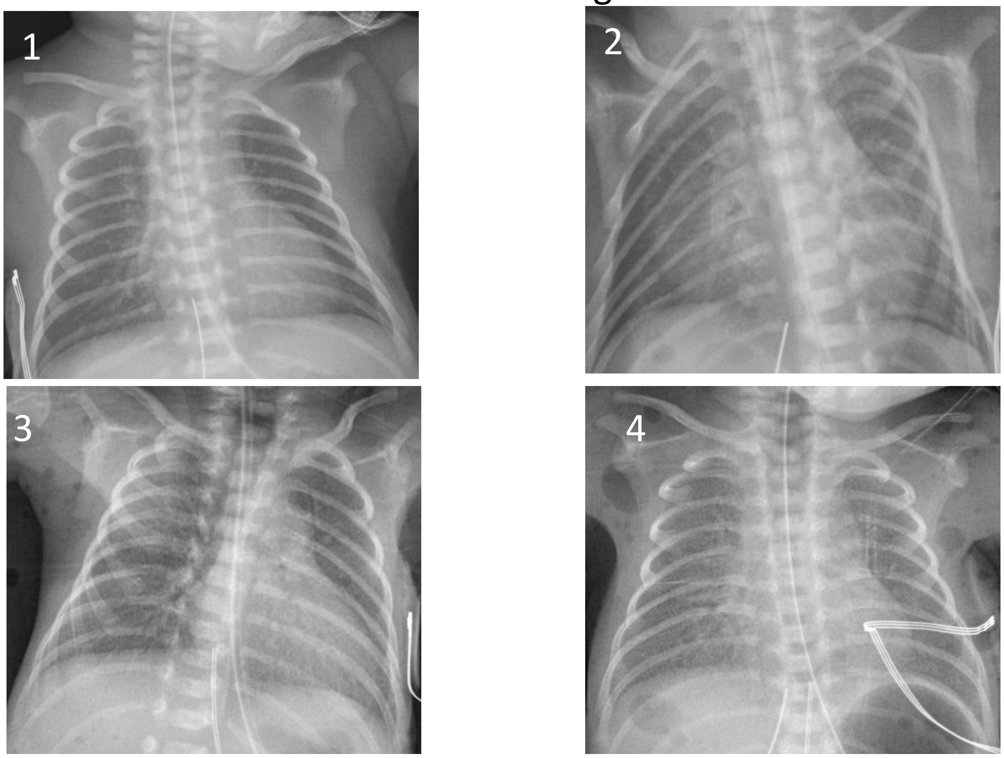
Image Diagnosis of RDS

Classic CXR findings: ground glass appearance



Non-specific CXR findings for RDS

What is the difference among these CXRs?

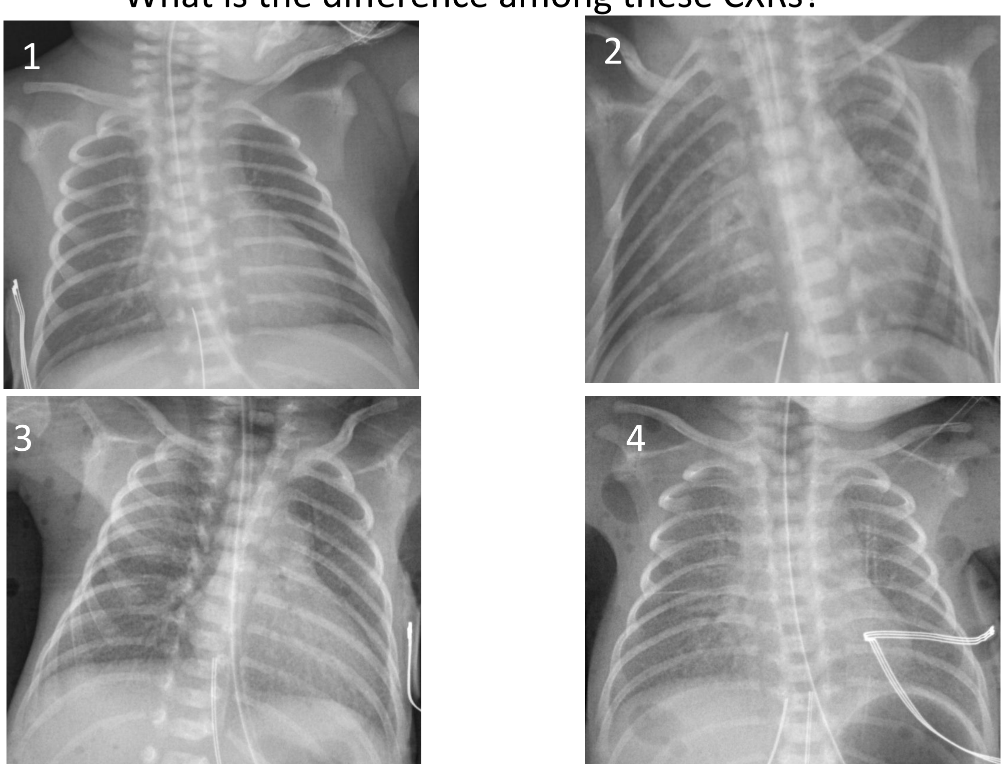


Non-specific CXR findings for RDS

What is the difference among these CXRs?

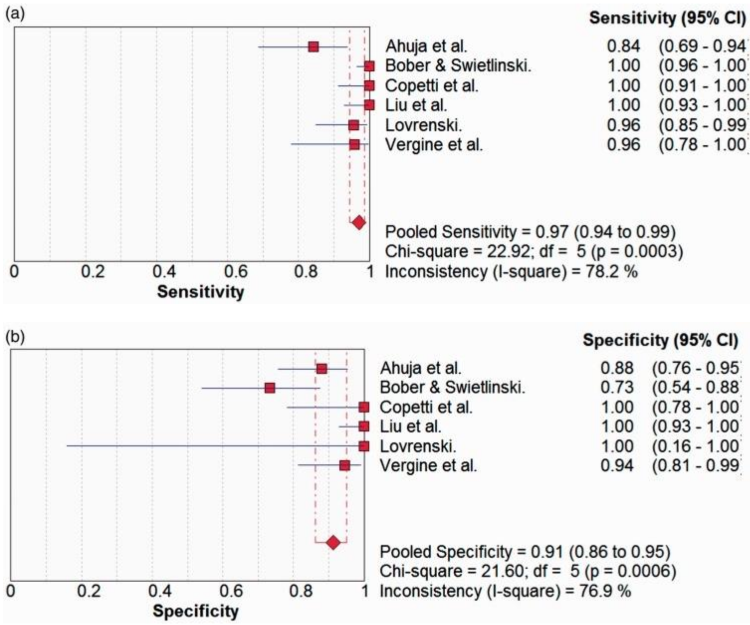
No need for Surf

Need for Surf



Chest X-ray (CXR) vs Lung Ultrasound (LUS)

LUS vs CXR and clinical information for diagnosing RDS

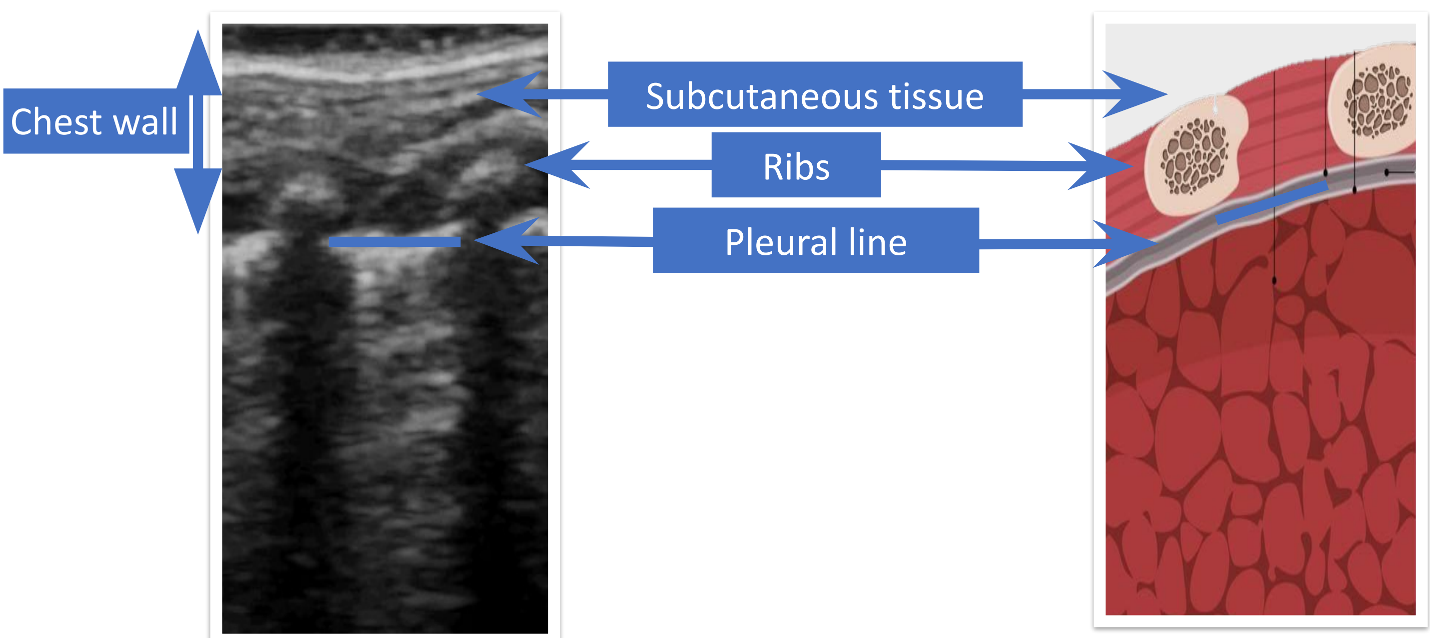


High sensitivity (97%)
High specificity (91%)

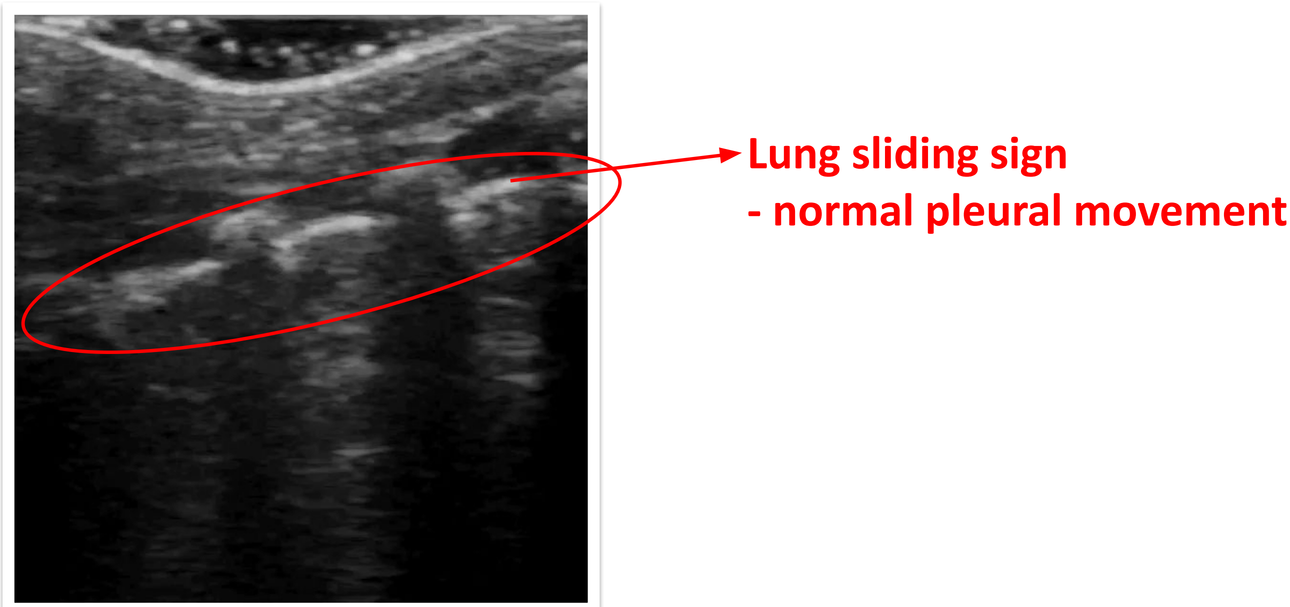
Evidence supports the use of LUS

Hiles M, et al. Neonatal respiratory distress syndrome: Chest X-ray or lung ultrasound? A systematic review. Ultrasound. 2017 May;25(2):80-91.

Normal Lung Ultrasound Image



Normal Lung Ultrasound Image



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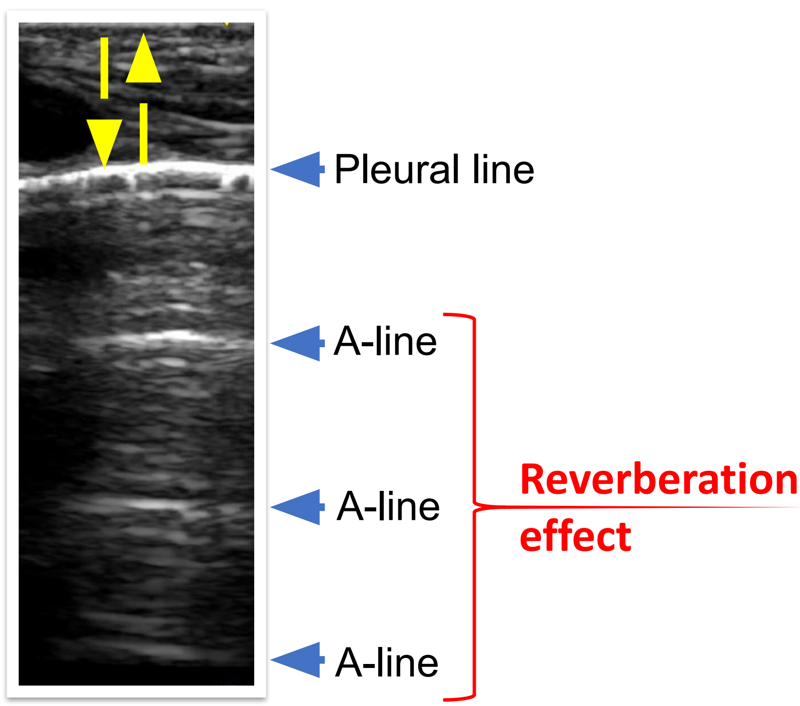
A Lines



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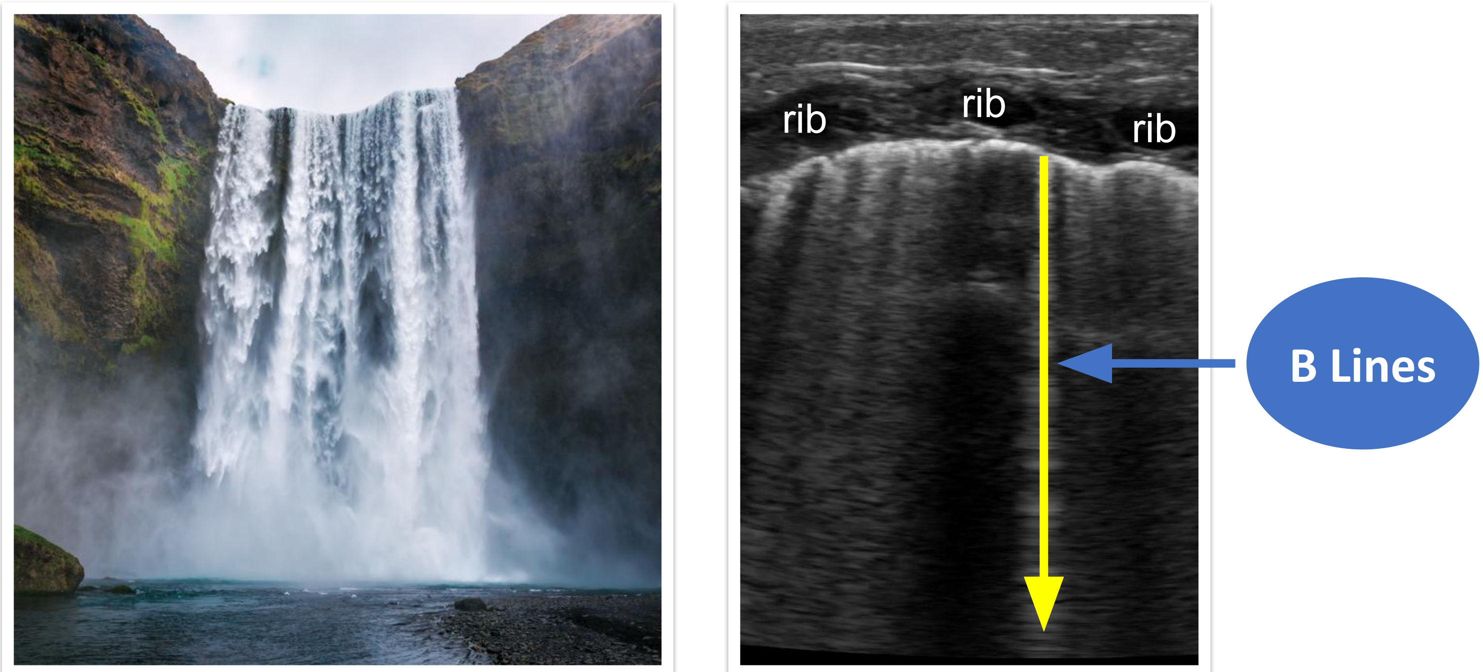
B Lines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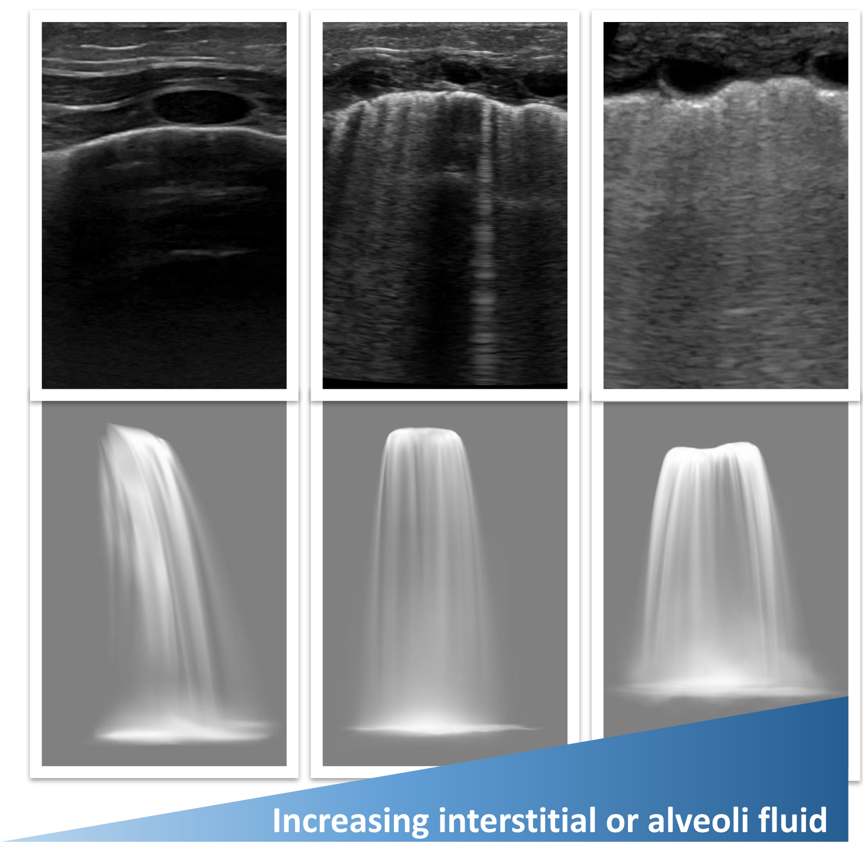
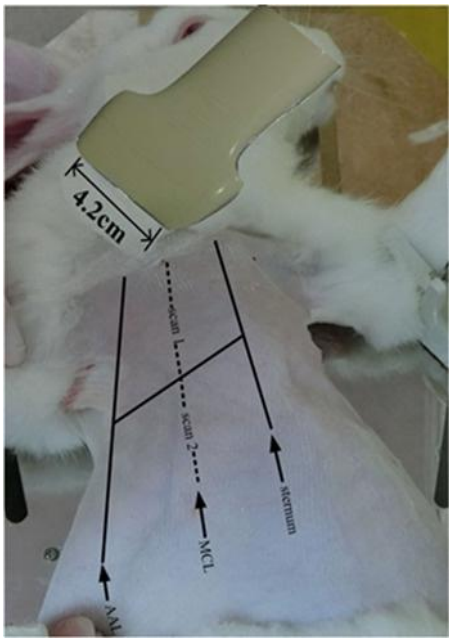
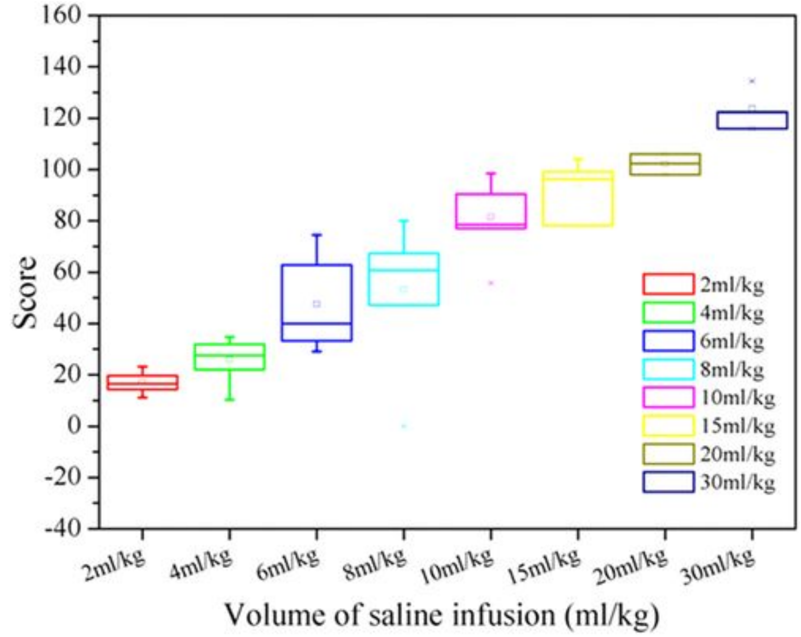
B Lines


Increasing interstitial or alveoli fluid

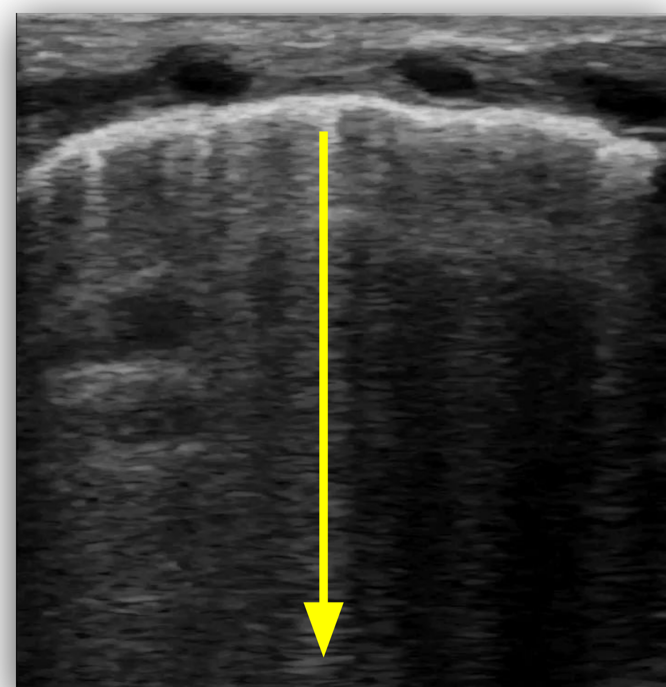
In vitro evidence:
LUS in assessing pulmonary edema





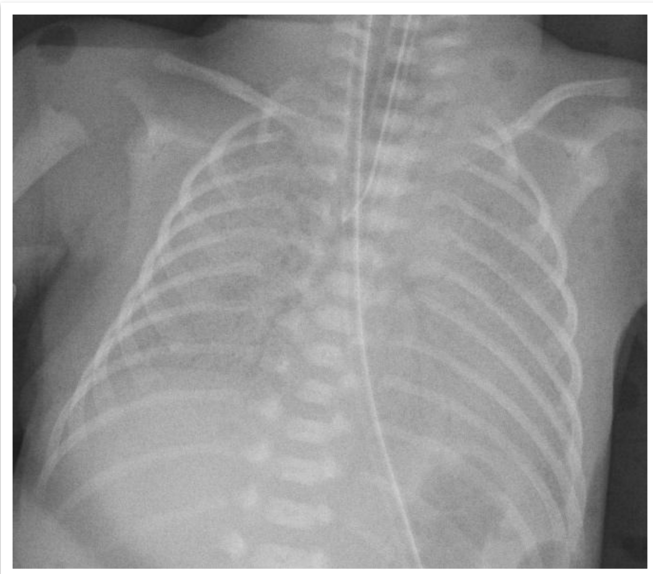
Zong HF, Guo G, Liu J, Bao LL, Yang CZ. Using lung ultrasound to quantitatively evaluate pulmonary water content. *Pediatr Pulmonol*. 2020;55(3):729-739. doi:10.1002/ppul.24635

B-lines are common in newborn's lungs

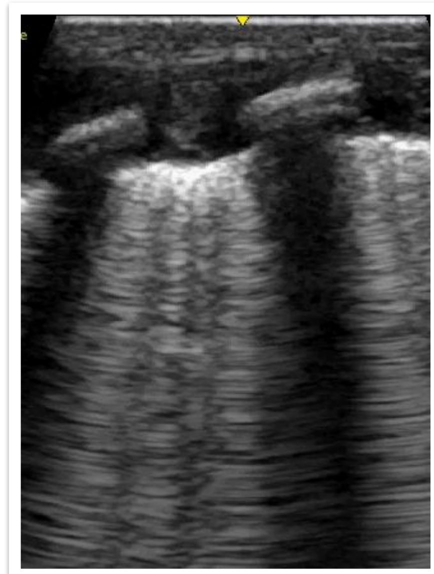


CXR vs LUS for diagnosing RDS

Classic CXR findings: ground glass appearance

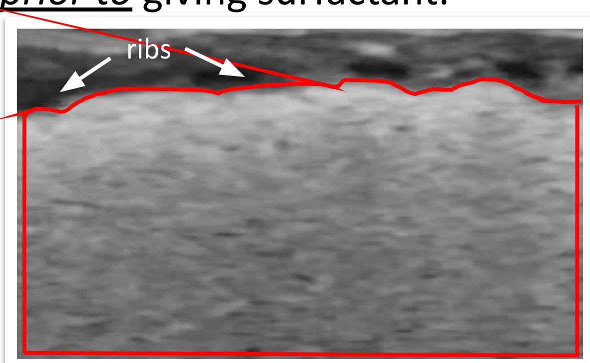


Classic US findings: confluence B lines "White out lung" in all areas of the lungs



LUS for RDS

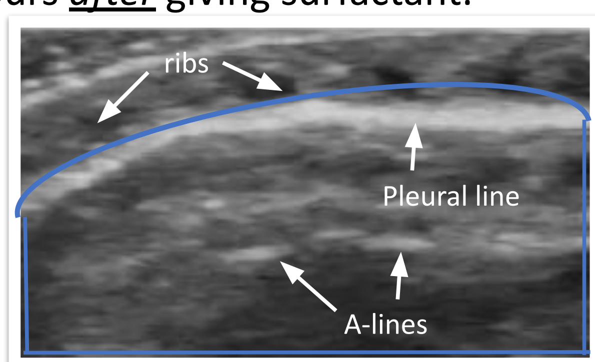
LUS of a preterm neonate with RDS *prior to* giving surfactant.



red boxed area shows confluent B lines (white lungs). Other findings of RDS:

- thickened and irregular pleural lines
- No spared area in all lung fields

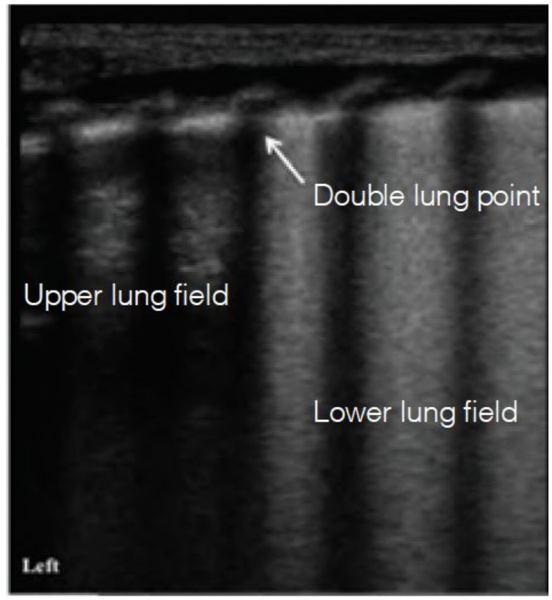
LUS of a preterm neonate with RDS 6 hours *after* giving surfactant.



These LUS findings resolve after giving surfactant, indicating improved lung aeration.

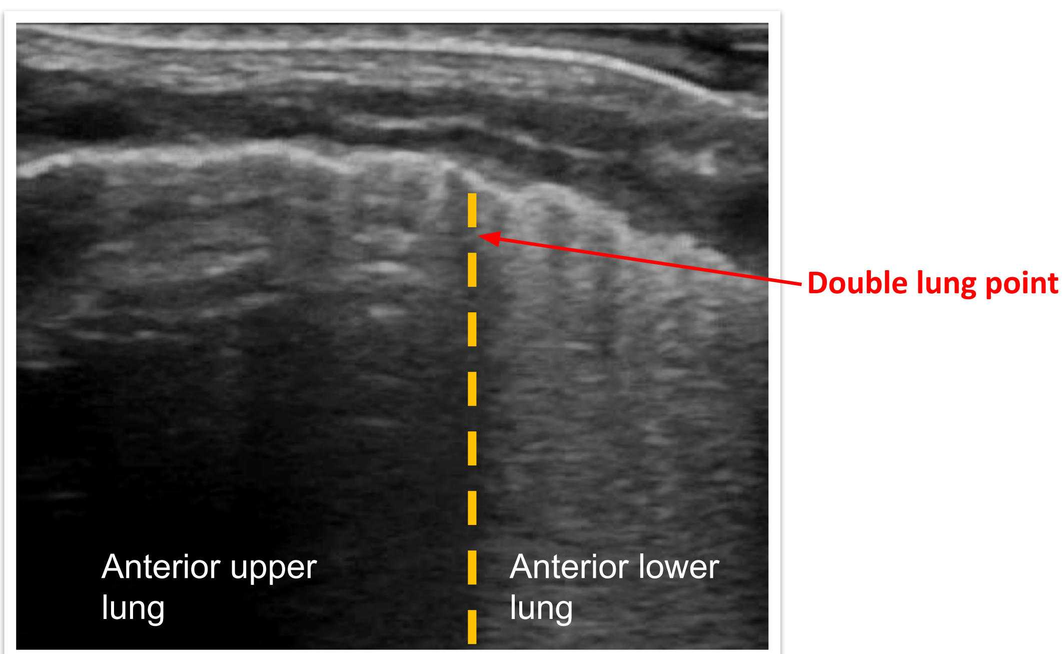
Transient tachypnea of newborn (TTN)

- Unlike RDS, TTN has areas of B lines sparing on LUS.
- A regular pleural line without consolidation.
- The transition point is called "**Double lung point**", which has a sensitivity of 46-78% and a specificity of 95-100% for TTN.

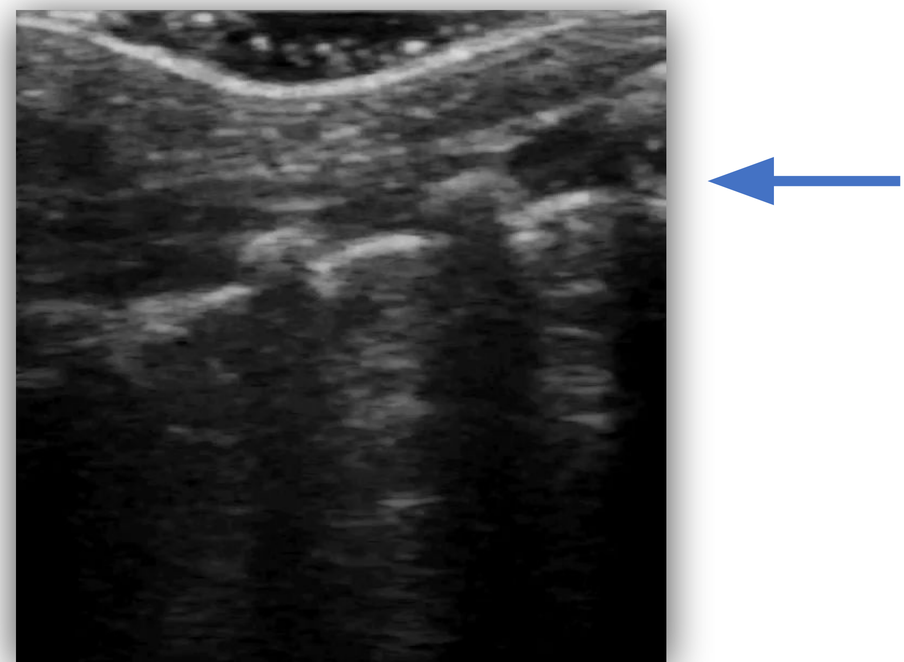


(Copetti et al 2007, Liu et al 2014, Liu et al 2016, Vergine et al 2014, Raimondi et al, 2019)

Transient Tachypnea of Newborn (TTN)



Lung Sliding

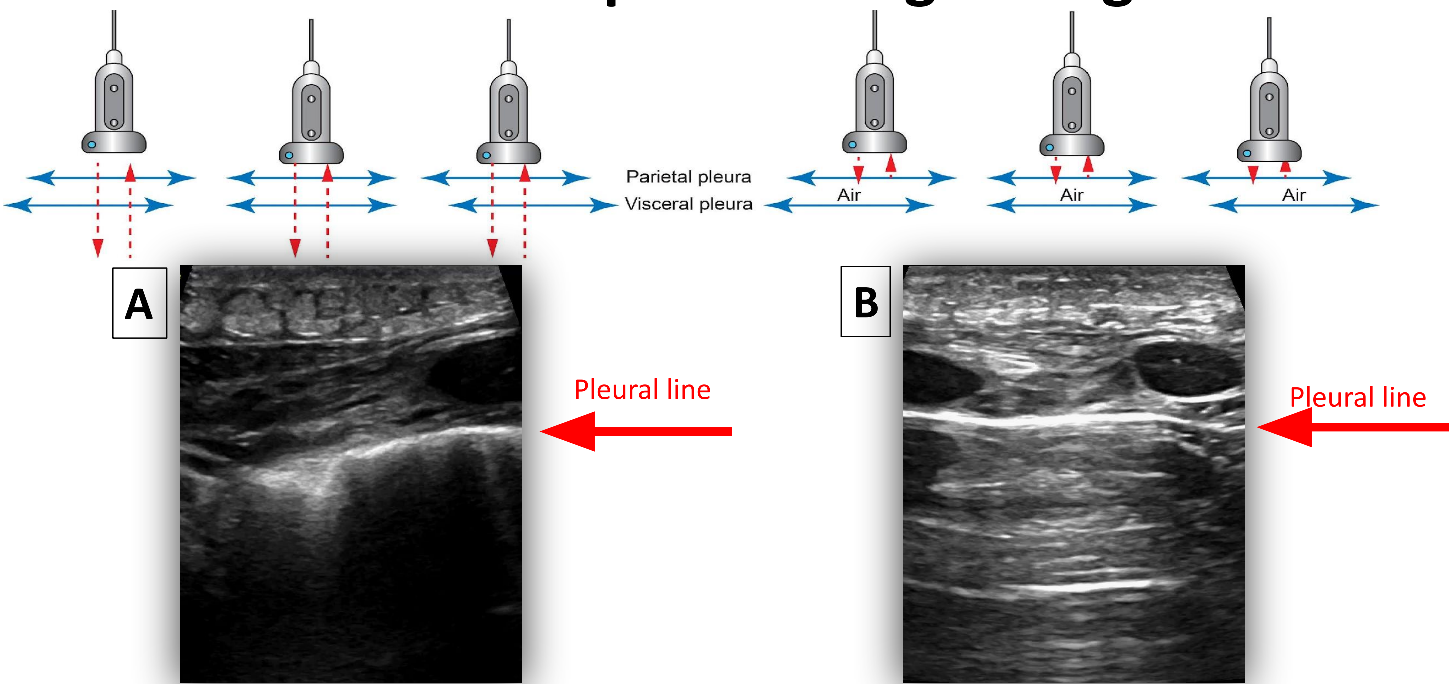


What is the clinical relevance of pleural line?

Pneumothor

ax

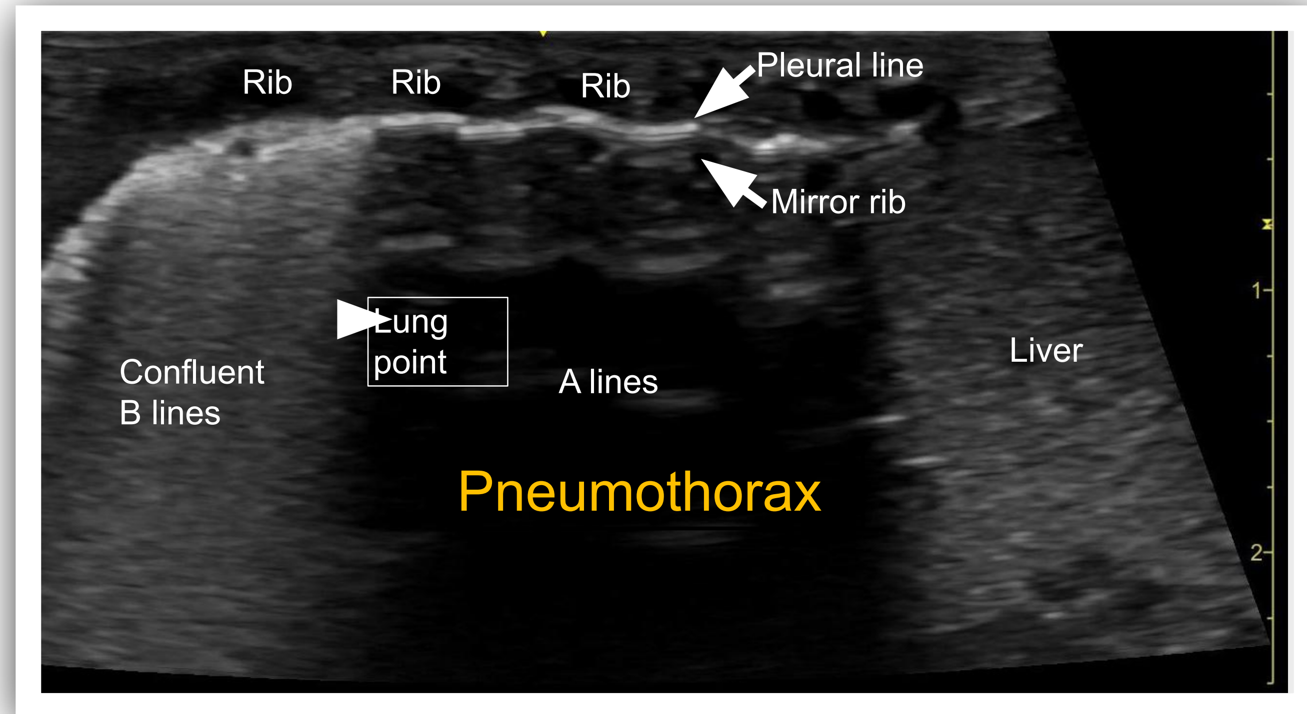
Look for the pleural lung sliding



Normal

Pneumothorax

Pneumothorax



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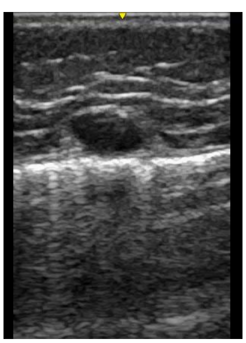
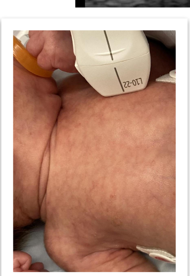
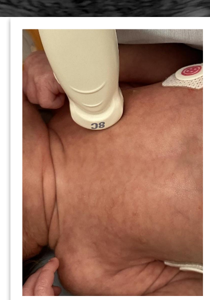
Probe selection

Linear

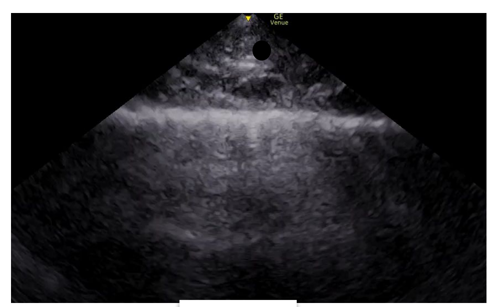




Microconvex



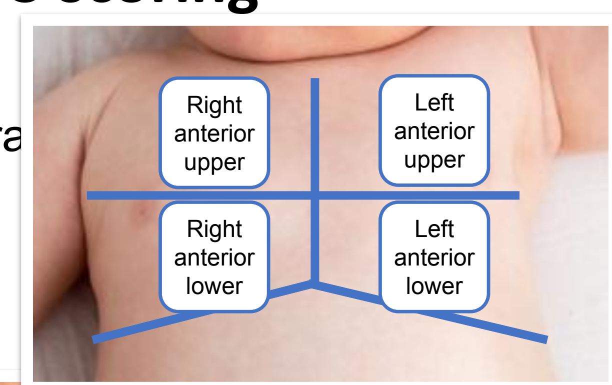
Phased Array

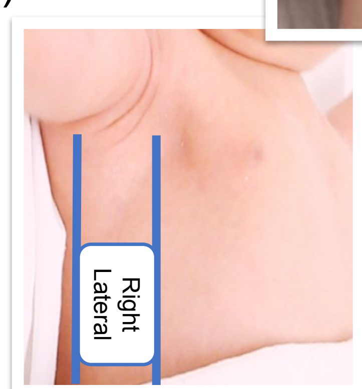


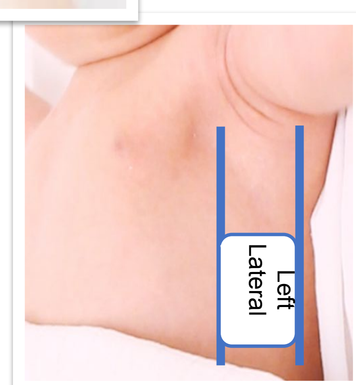
Corsini et al pediatric pulmonology 2020;55:155--1562

LUS scoring

- Scan 3 areas in each hemithora
  - Upper anterior (R1, L1)
  - Lower anterior (R2, L2)
  - Lateral (R3, L3)

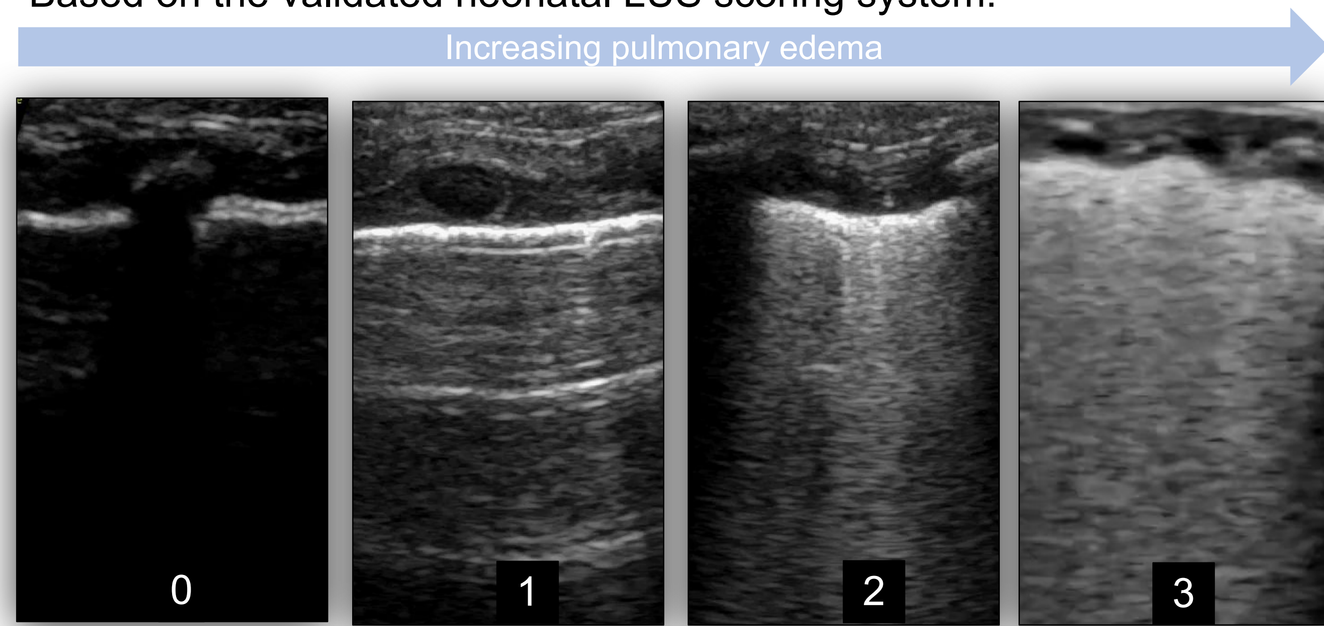






LUS scoring (0-3)

Based on the validated neonatal LUS scoring system:[1]



Brat, R. et al. JAMA pediatrics 169 8 (2015): e151797

LUS scoring

- Assign LUS score to each area – in all 6 areas
- Add up all the scores (max 18)

R1+R2+R3+L1+L2+L3 = total LUS score

Non-specific CXR findings for RDS

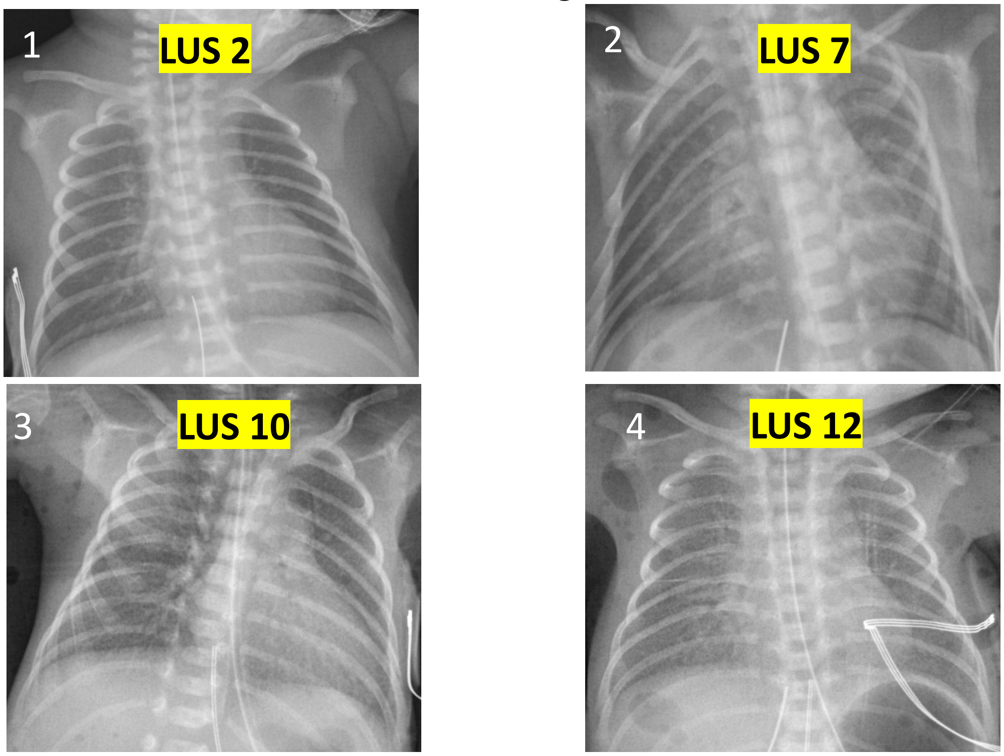
What is the difference among these CXRs?

No need for Surf

LUS score <10

Need for Surf

LUS score ≥ 10



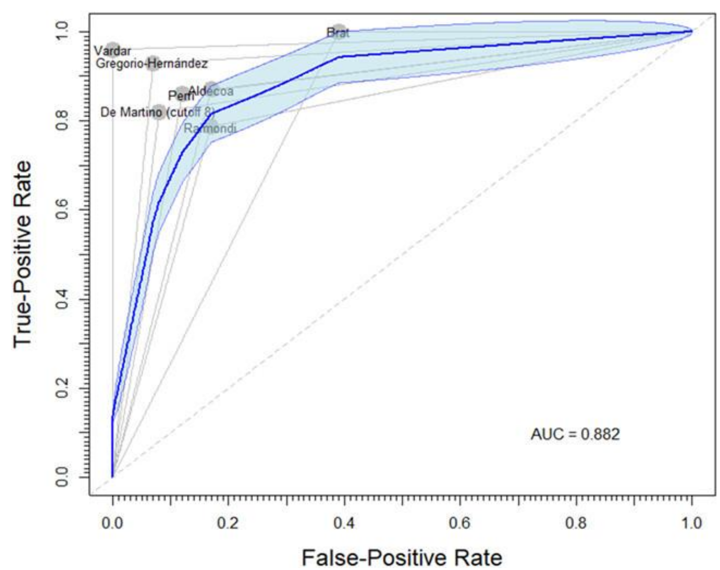
LUS scoring predicts the need for surfactant

ROC curve for LUS in predicting the need for surfactant with cut-off 8 out of 18 (n=697):

AUC = 0.882 (95% CI: 0.826–0.917)

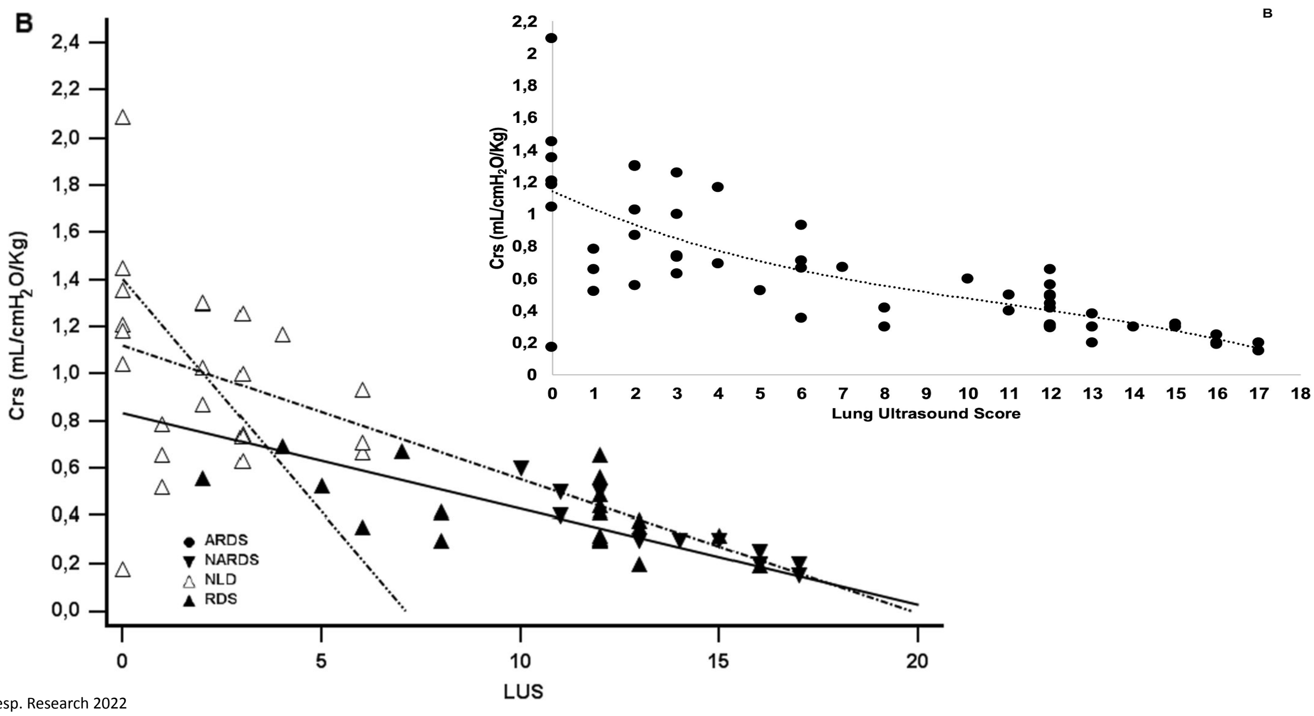
Sensitivity = 84% (p<0.0001)

Specificity = 93% (p<0.0001)



Capasso L, at al. (2023). *Pediatric pulmonology*, *58*(5), 1427–1437.

LUS score correlates with Lung Compliance



Biasucci DG et al. Resp. Research 2022

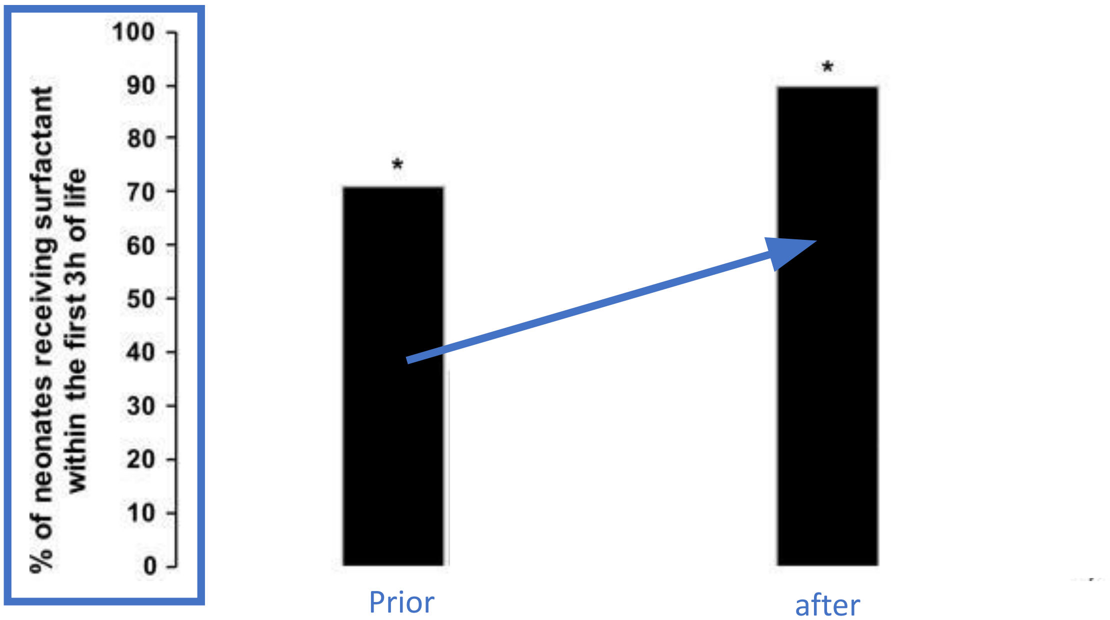
Interobserver agreement

Table 2. Interobserver Agreement Between Main and Expert, Intermediate, and Beginner Control Interpreters

Interobserver Agreement	κ1 (95% CI)	κ2 (95% CI)	κ3 (95% CI)
General	0.94 (0.88–1.00)	0.72 (0.61–0.83)	0.81 (0.71–0.90)
RDS specific	0.94 (0.87–1.00)	0.90 (0.81–0.99)	0.87 (0.78–0.97)
TTN specific	0.95 (0.89–1.00)	0.76 (0.64–0.88)	0.81 (0.70–0.91)

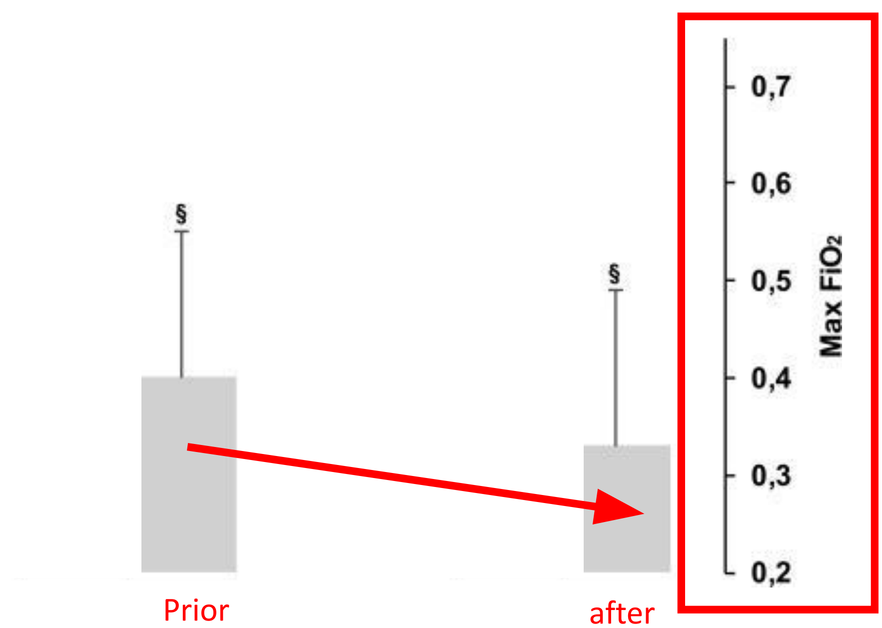
Gomond-Le Goff C, et al. Effect of Different Probes and Expertise on the Interpretation Reliability of Point-of-Care Lung Ultrasound. *Chest.* 2020;157(4):924-931. doi:10.1016/j.chest.2019.11.013

Echography-guided surfactant therapy to improve timeliness of surfactant replacement.



Raschetti R, et al. J. Pediatr. 2019.

Echography-guided surfactant therapy to improve timeliness of surfactant replacement.



Raschetti R, et al. J. Pediatr. 2019.

Practical application to your unit

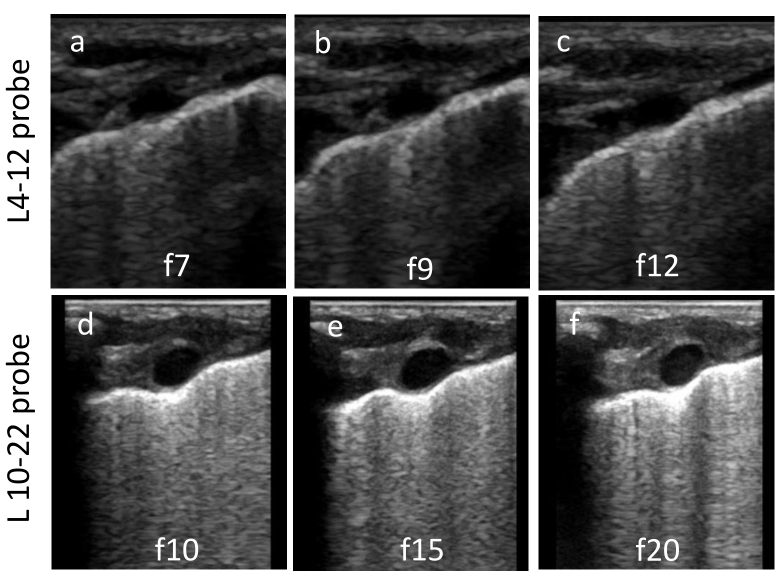
Original Article

Substantiating and Adopting Lung Ultrasound Scores to Predict Surfactant Need in Preterm Neonates with Respiratory Distress Syndrome within an Institution

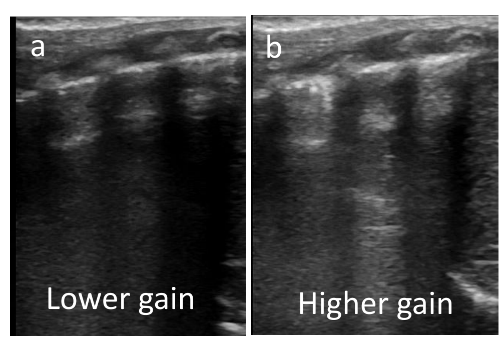
Belinda Chan, MD[1,2] Christopher Torsitano, MD[1,2] Sasha Gordon, BS, RDMS, RVT[3]
Olive Konana, MD[4] Yogen Singh, MD[5]

Am J Perinatol. 2024 sep;41(12_:1652-1659

Ultrasound machine variation



Probe frequency variation



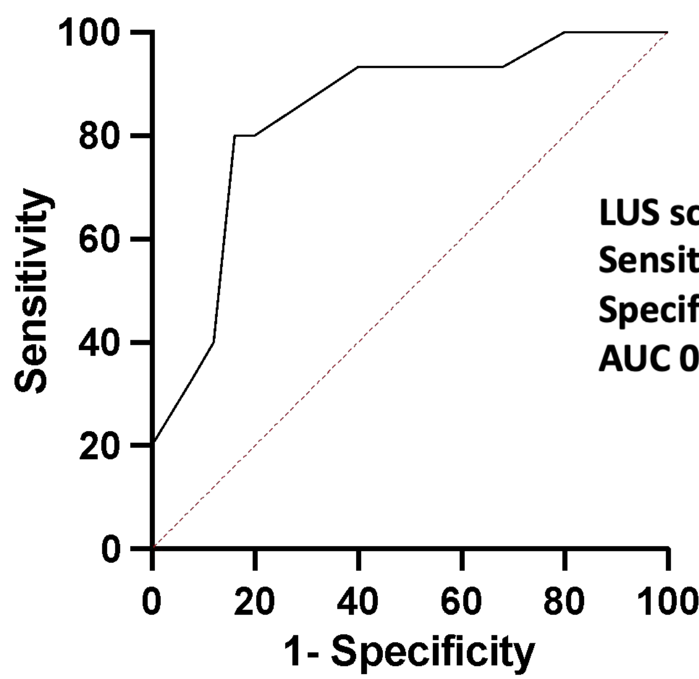
Gain setting variation

Results:

Table 1 Neonates' demographics and clinical characteristics

	Surf ($n = 15$)	Non-Surf ($n = 25$)	p-Value
Gestational age (weeks), median (IQR)	30 (27, 32)	30 (29, 32)	0.38[a]
Birth weight (kg), median (IQR)	1.3 (1.1, 1.9)	1.5 (1.4, 1.8)	0.42[a]
Male, n (%)	10 (67)	12 (48)	0.33[b]
Prenatal steroid, n (%)	13 (87)	22 (88)	>0.99[b]
C-section, n (%)	10 (67)	14 (58)	0.74[b]
Apgar at 5 minutes, median (IQR)	8 (7, 9)[c]	8 (8, 9)	0.18[a]
Age at LUS done (hours), median (IQR)	0.5 (0.25, 1.5)	1 (0.5, 2.5)	0.11[a]
Respiratory Silverman Score, median (IQR)	6 (3, 6)	2 (1, 4)	0.006[a]
FiO_2 at LUS done (%), median (IQR)	40 (32, 41)	23 (21, 29)	<0.001[a]
SpO_2/FiO_2 at LUS done, median (IQR)	241 (205, 298)	418 (327, 457)	<0.001[a]
LUS score, median (IQR)	10 (10, 13)	6 (5, 8)	<0.001[a]
Maximum FiO_2 in the first 72 hours of life, median (IQR)	55 (40, 70)	40 (30, 43)	0.003[a]
Duration of FiO_2 >30% (hours) in the first 72 hours of life, median (IQR)	9.8 (1.5, 21.6)	0.5 (0.25, 1.0)	<0.001[a]

ROC curve for predicting surfactant need



LUS score cut off≥ 10
Sensitivity 80%
Specificity 84%
AUC 0.8 (95% CI 0.7-1, p=0.0003)

Conclusion

- LUS is a helpful adjunct in diagnosing RDS
- LUS can help in early prediction of need of surfactant therapy
- A pragmatic approach is needed for clinical implementation

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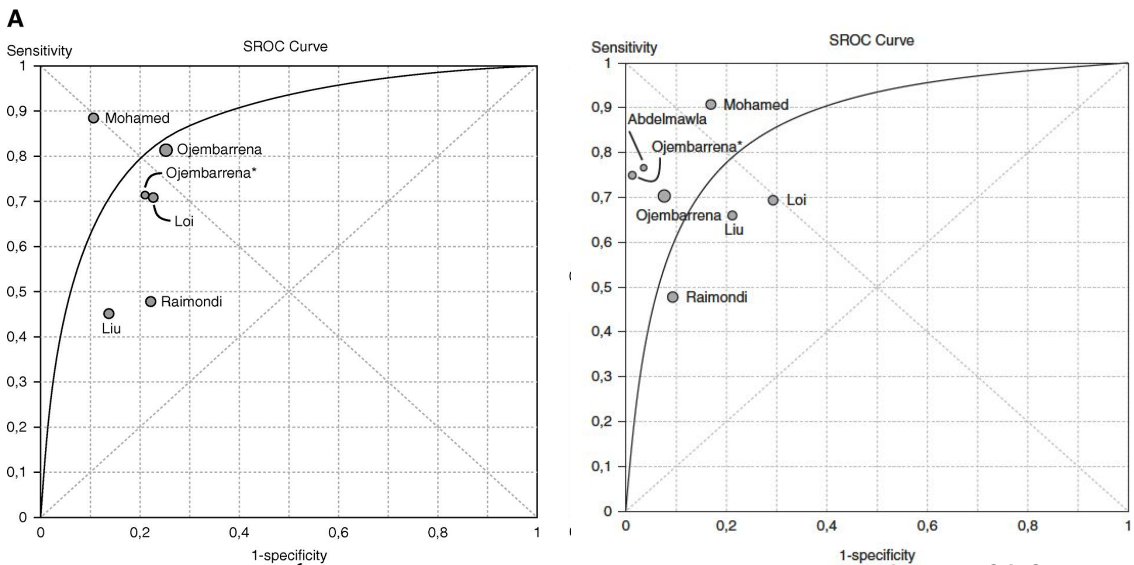
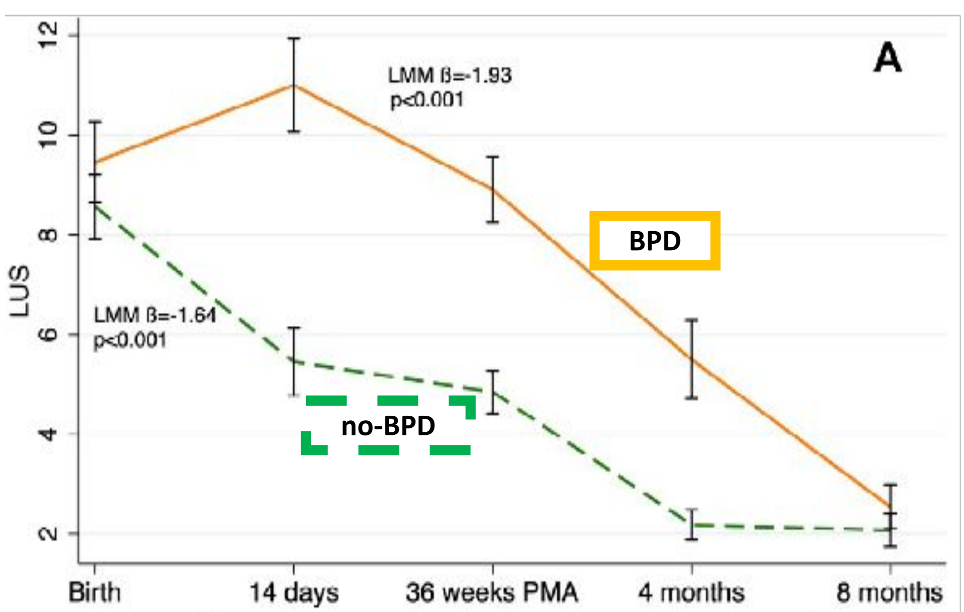
Predicts Bronchopulmonary Dysplasia



LUS at 7 days of life **LUS at 14 days of life**

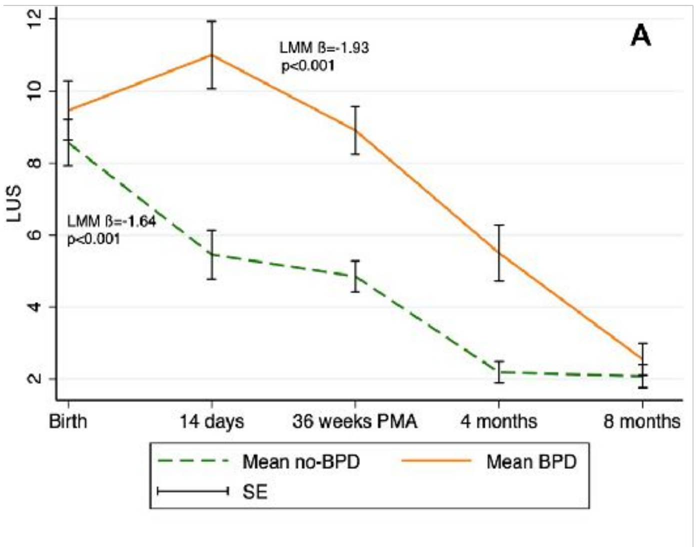
Pezza L et al, Ann Am Thor Soc 2022

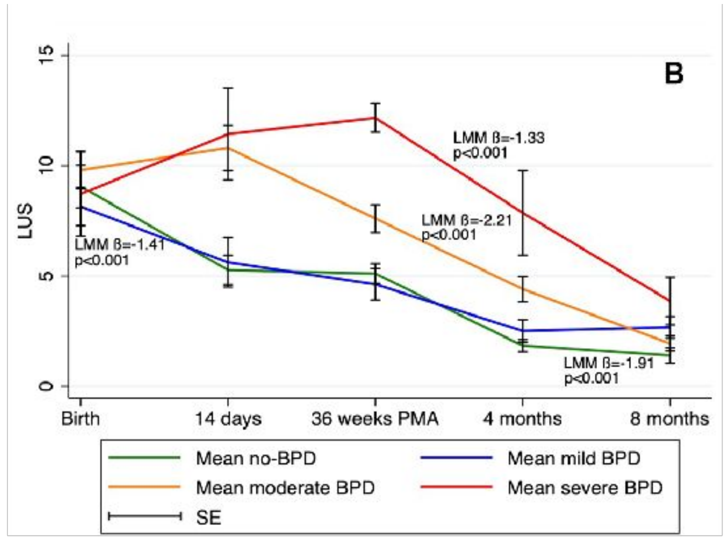
Predicts Bronchopulmonary Dysplasia



Savoia M et al, Eur J Pediatr 2022

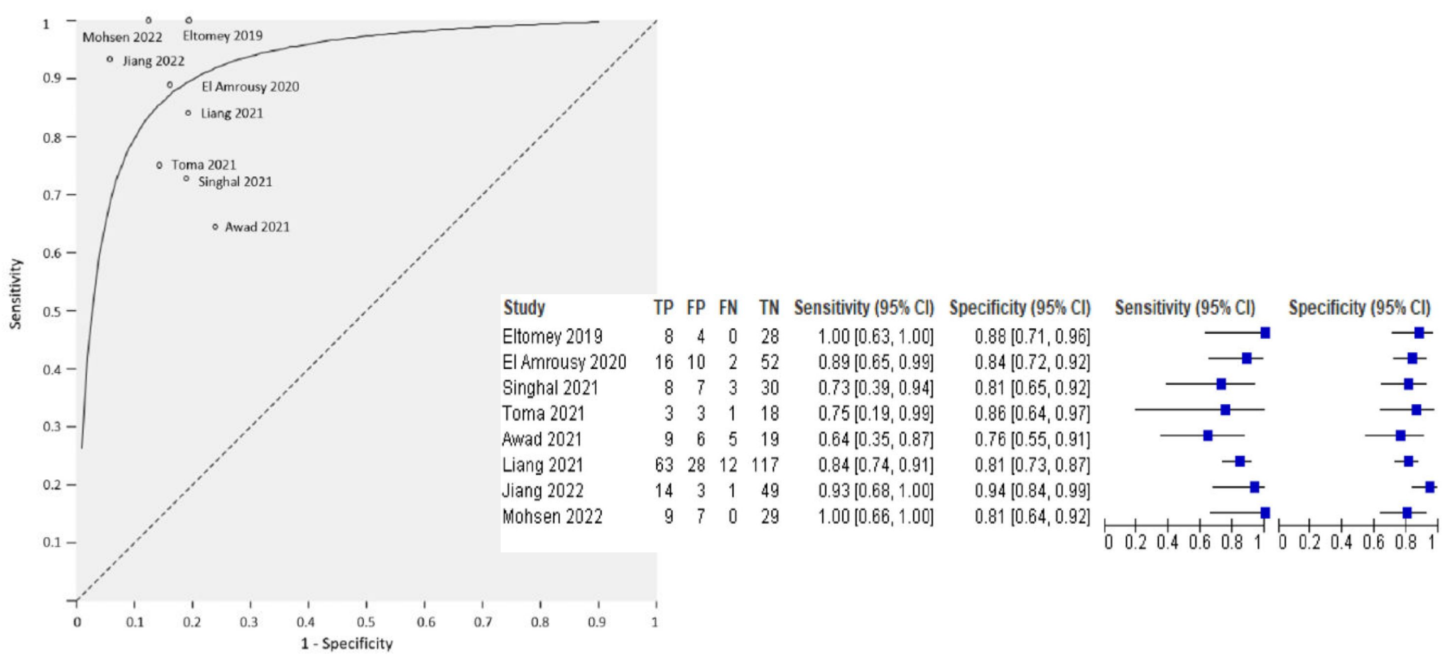
Predicts Bronchopulmonary Dysplasia





Savoia M et al, Eur J Pediatr 2022

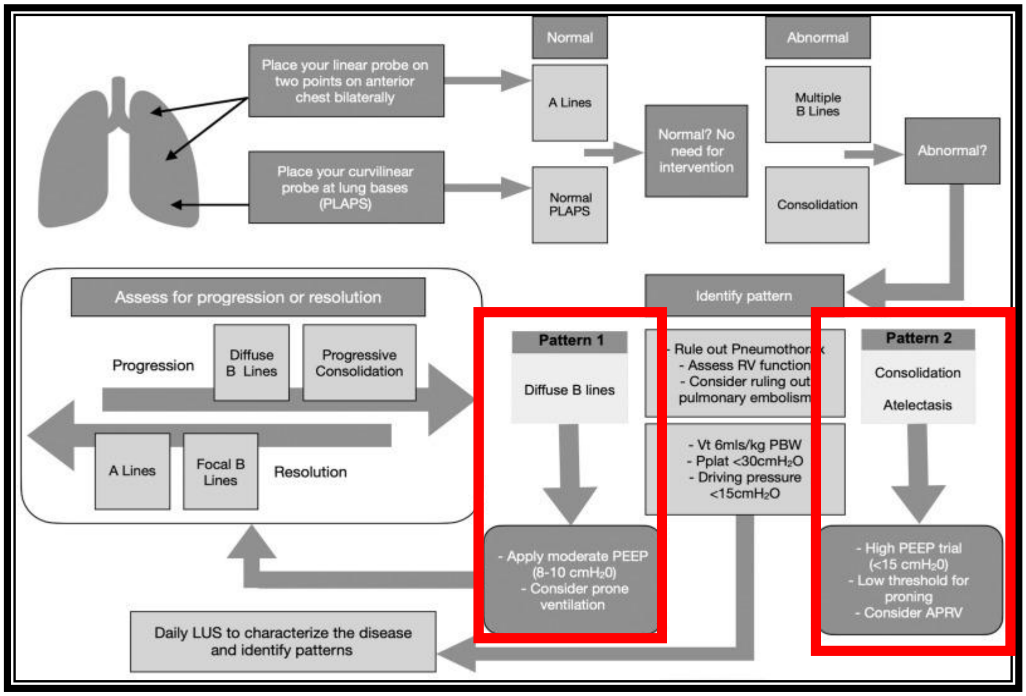
Predicts extubation failure in neonates



Study	TP	FP	FN	TN	Sensitivity (95% CI)	Specificity (95% CI)
Eltomey 2019	8	4	0	28	1.00 [0.63, 1.00]	0.88 [0.71, 0.96]
El Amrousy 2020	16	10	2	52	0.89 [0.65, 0.99]	0.84 [0.72, 0.92]
Singhal 2021	8	7	3	30	0.73 [0.39, 0.94]	0.81 [0.65, 0.92]
Toma 2021	3	3	1	18	0.75 [0.19, 0.99]	0.86 [0.64, 0.97]
Awad 2021	9	6	5	19	0.64 [0.35, 0.87]	0.76 [0.55, 0.91]
Liang 2021	63	28	12	117	0.84 [0.74, 0.91]	0.81 [0.73, 0.87]
Jiang 2022	14	3	1	49	0.93 [0.68, 1.00]	0.94 [0.84, 0.99]
Mohsen 2022	9	7	0	29	1.00 [0.66, 1.00]	0.81 [0.64, 0.92]

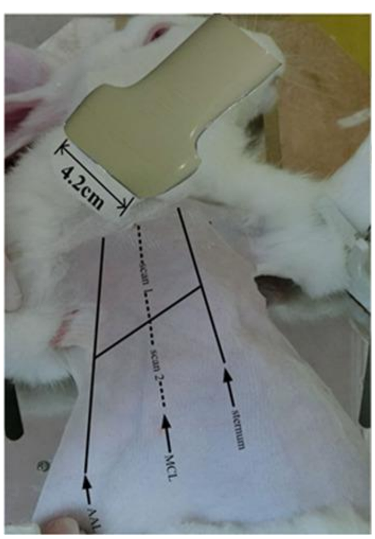
Mohsen N, et al. Accuracy of lung ultrasound in predicting extubation failure in neonates: A systematic review and meta-analysis. *Pediatr Pulmonol*. 2023;58(10):2846-2856. doi:10.1002/ppul.26598

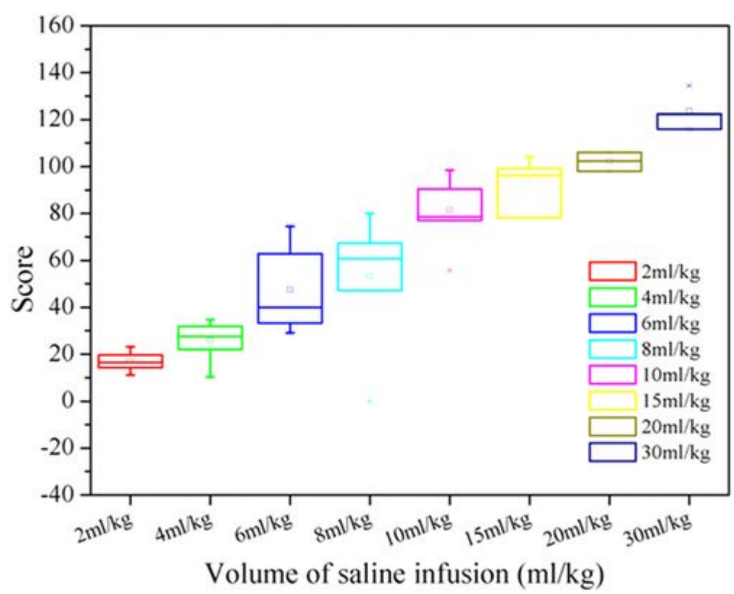
LUS in ventilator management



Conway H, et al. Personalizing Invasive Mechanical Ventilation Strategies in Coronavirus Disease 2019 (COVID-19)-Associated Lung Injury: The Utility of Lung Ultrasound. *J Cardiothorac Vasc Anesth*. 2020;34(10):2571-2574.

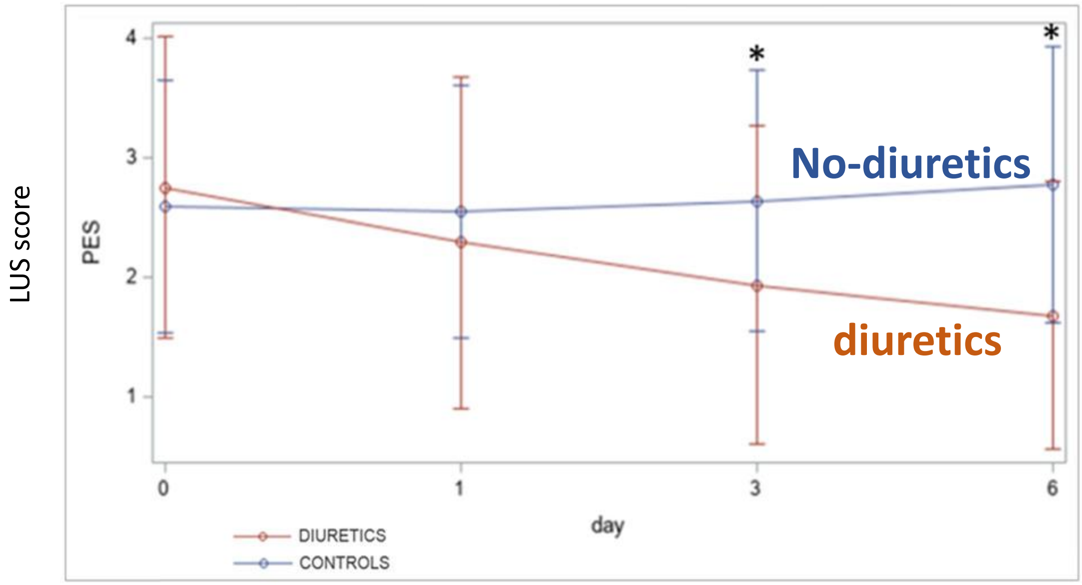
LUS in assessing pulmonary edema





Zong HF, Guo G, Liu J, Bao LL, Yang CZ. Using lung ultrasound to quantitatively evaluate pulmonary water content. *Pediatr Pulmonol*. 2020;55(3):729-739. doi:10.1002/ppul.24635

Pulmonary edema in preterm neonates with chronic lung disease before and after diuretic therapy (n=51)



Kasniya G, et al. Lung ultrasound assessment of pulmonary edema in neonates with chronic lung disease before and after diuretic therapy. *Pediatr Pulmonol*. 2022;57(12):3145-3150.

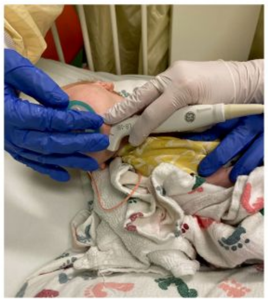
LUS score in neonates with PDA

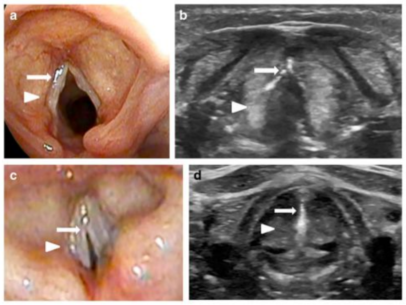
Comparison of patient characteristics between patent ductus arteriosus and ductus arteriosus closure groups.

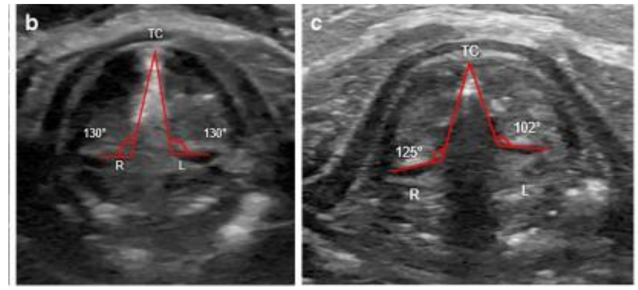
Group	N	Age (days)	Gestational age (weeks)	Weight (kg)	AO/LA	EF (%)	Hospital stay length (days)	LUS
Patent ductus arteriosus	127	4.13±1.12	30.90±3.56	1.56±0.63	0.83±0.12	63.38±5.88	33.09±23.20	8.88±3.56
Ductus arteriosus closure	94	4.50±1.26	30.33±2.81	1.43±0.48	0.88±0.14	64.31±5.95	35.71±19.66	6.75±3.66
t		0.776	13.094	15.819	0.085	0.012	4.784	0.005
P		0.444	0.199	0.087	0.001	0.249	0.377	0.000

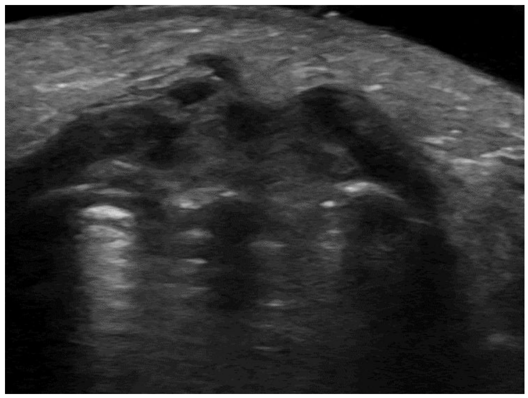
Zhao M, Huang XM, Niu L, Ni WX, Zhang ZQ. Lung Ultrasound Score Predicts the Extravascular Lung Water Content in Low-Birth-Weight Neonates with Patent Ductus Arteriosus. *Med Sci Monit*. 2020;26:e921671.

Vocal Cords









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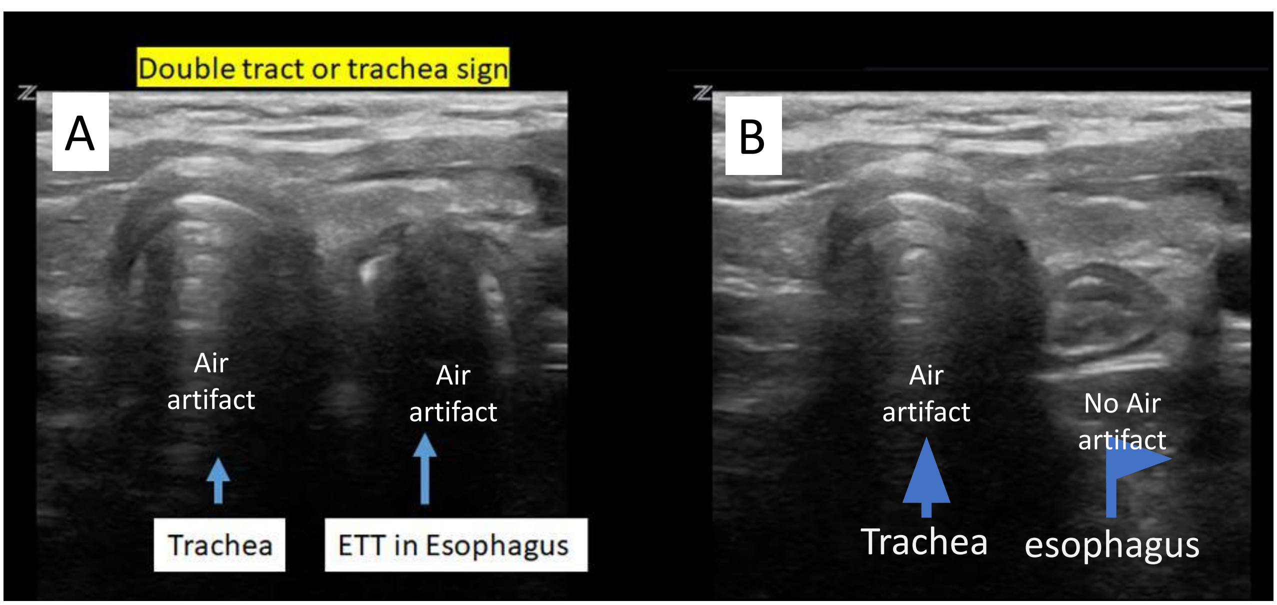
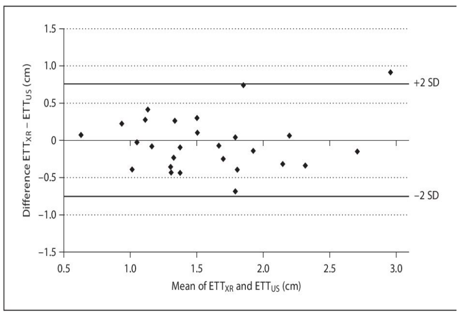
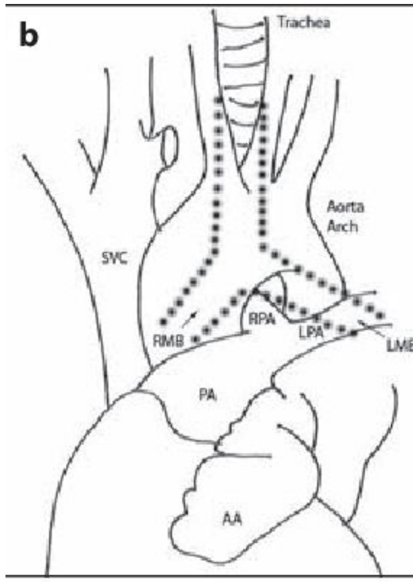
Endotracheal tube position

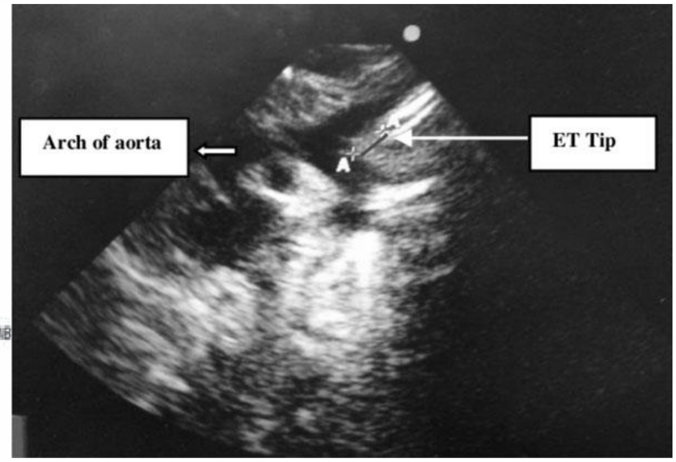


https://www.aliem.com/pem-pocus-series-confirmation-endotracheal-tube/

Endotracheal tube position







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