Retrospective analysis of the diagnostic accuracy of lung ultrasound for pulmonary embolism in patients with and without pleuritic chest pain

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Background

- Pleuritic chest pain is a common presenting symptom in the emergency department that requires a careful differential diagnosis
- Lung ultrasound (LUS) has a role in the diagnosis of pulmonary embolism (PE) mainly based on the visualization of pulmonary infarctions

Lung infarction

Pleural based anechoic consolidation, wedge or round shaped, with sharp margins, without air bronchograms, of a minimum size measured at the pleural level of 0.5 cm with or without an associated small pleural effusion
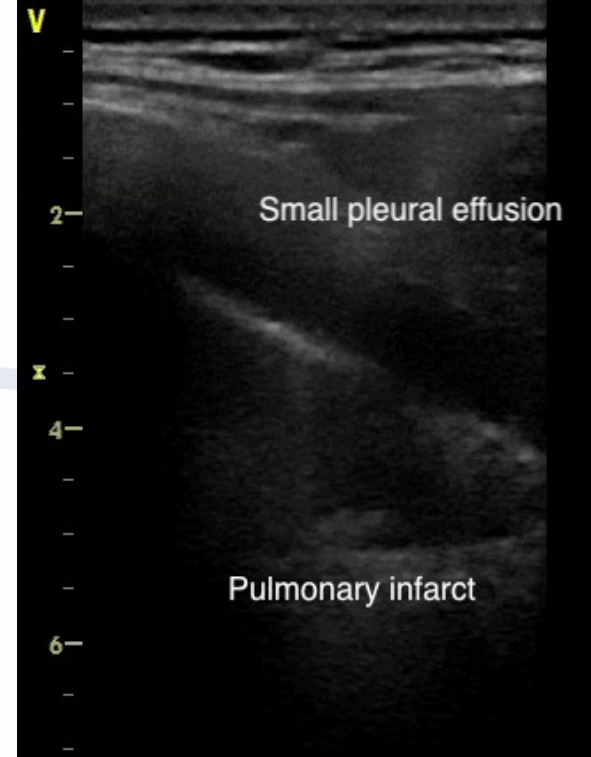
Aim of our study

- Compare sensitivity and specificity of LUS in patients with and without pleuritic chest pain
- Compare sensitivity and specificity of global chest LUS examination approach versus a single LUS scan performed in the most painful area
- Compare two pre-test strategies for the prediction of PE: Wells score + d-dimer versus Wells score +LUS

Methods

Characteristics of source studies

Study	Design	Population, n	Lung US criteria for PE diagnosis	Reference test for PE diagnosis	Blinded adjudication of diagnosis	Follow-up
Reissig 2001 (14)	Monocenter, prospective cohort study	Patients suspected of PE, 69	At least one pulmonary infarct defined as well-demarcated wedge-shaped or rounded lesions	MCTPA or combination of other diagnostic tests or autopsy	Yes	Yes
Nazerian 2014 (13)	Multicenter, prospective cohort study	Patients presenting to ED, suspected of PE and with a Wells score >4 or a positive D-dimer, 357	At least one pulmonary infarct defined as pleural based, well-demarcated echopoor triangular or rounded consolidations of at least 0.5 cm in size	MCTPA performed in ED	Yes	No
Nazerian 2017 (15)	Multicenter, prospective cohort study	Patients presenting to ED with suspected PE, 446	At least one pulmonary infarct defined as pleural based, well-demarcated echopoor triangular or rounded consolidations of at least 0.5 cm in size	Second level imaging diagnostic test or autopsy	Yes	Yes

US: ultrasonography; ED: emergency department; CT: computed tomography;

Results

Final diagnosis in all patients and in patients with and without pleuritic chest pain

	All patients n=872	No pleuritic chest pain, n=655	Pleuritic chest pain, n=217
Pulmonary embolism	279 (32%)	214 (32.7%)	65 (30%)
Pneumonia	169 (19.4%)	121 (18.5%)	48 (22.1%)
Heart failure	80 (9.2%)	72 (11%)	8 (3.7%)
Muscolo-skeletal chest pain	53 (6.1%)	11 (1.7%)	42 (19.4%)
COPD / pulmonary fybrosis	60 (6.9%)	55 (8.4%)	5 (2.3%)
Pleural effusion	38 (4.4%)	21 (3.2%)	17 (7.8%)
Syncope	37 (4.2%)	35 (5.3%)	2 (0.9%)
Tachyarrhythmia	32 (3.7%)	27 (4.1%)	5 (2.3%)
Acute coronary syndrome	19 (2.2%)	17 (2.6%)	2 (0.9%)
Lung cancer	20 (2.3%)	13 (2%)	7 (3.2%)
Psycogenic dyspnea	19 (2.2%)	16 (2.4%)	3 (1.4%)
Aortic dissection	6 (0.7%)	6 (0.9%)	0
Pericardial effusion	5 (0.6%)	3 (0.5%)	2 (0.9%)
Miscellaneous	55 (6.3%)	44 (6.7%)	11 (5.1%)

COPD= Chronic Obstructive Pulmonary Disease

Results

Diagnostic performance of lung ultrasonography for the diagnosis of PE in all patients and in patients without and with pleuritic chest pain

Population, n	Sens % (95% CI)	Spec % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	LR+ (95% CI)	LR- (95% CI)
All patients, 872	57% (51-62.9)	94.9% (92.9-96.6)	84.1% (78.1-89)	82.4% (79.4-85.2)	11.3 (7.83-16.20)	0.45 (0.40-0.52)
No pleuritic chest pain, 655	49.5% (42.7-56.4)	94.8% (92.3-97.7)	82.2% (74.5-88.4)	79.5% (75.8-82.8)	9.50 (6.24-14.46)	0.53 (0.47-0.61)
Pleuritic chest pain, 217	81.5% (70-90.1)	95.4% (90.7-98.1)	88.3% (77.4-95.2)	92.4% (87-96)	17.71 (8.51-36.84)	0.19 (0.11-0.31)
Scan in the most painful area, 156*	78.7% (64.3-89.3)	95.4% (89.6-98.5)	88.1% (75.6-99.6)	91.2% (85.7-94.7)	17.16 (7.2-40.92)	0.22 (0.13-0.39)

Sens= Sensibility; Spec= Specificity; PPV= Positive Predictive Value; NPV= Negative Predictive Value; LR+= Positive Likelihood Ratio; LR-= Negative

Likelihood Ratio *Patients with pleuritic chest pain recruited in the study by Reissig and Nazerian 2017

- Sn of LUS with and without pleuritic chest pain: 81.5% vs 49.5%, *p<0.001*

- Sp of LUS with and without pleuritic chest pain: 95.4% vs 94.8%, *p=0.86*

- Sn of simplified LUS and whole chest LUS: 78.7% vs 83%, *p=0.48*

- Sp of simplified LUS and whole chest LUS: 95.4% vs 94.5%, *p=1*

Results

Comparison of different diagnostic strategies incorporating Wells score, d-dimer measurement and LUS in 451 patients from Reissig 2001 and Nazerian 2017 study

	Wells score ≤4 and negative d-dimer	Wells score ≤4 and negative LUS
Failure rate^ % (95% CI)	4.1 (1.4-9.4)	12.4 (8.5-17.4)
Efficiency+ % (95% CI)	26.8 (22.8-31)	51.7 (46.9-56.4)
Sensitivity % (95% CI)	96.6 (92.3-98.9)	80.5 (73.3-86.6)
Specificity % (95% CI)	38.4 (32.9-44.1)	67.5 (61.9-72.8)
PPV % (95% CI)	43.5 (41.2-45.8)	55 (50.6-59.5)
NPV % (95% CI)	95.9 (90.6-98.2)	87.6 (83.9-91.2)
LR+	1.57 (1.43-1.72)	2.48 (20.07-2.97)
LR-	0.09 (0.04-0.21)	0.29 (0.21-0.41)

LUS= Lung ultrasound; PPV= Positive predictive value; NPV= Negative predictive value; 95% CI= 95% confidence interval.
^ Calculated as the number of patients within the group with a final diagnosis of PE divided by all patients in the same group
+ Calculated as the number of patients within the group divided by all included patients

- Failure rate Wells + d-dimer vs Wells + LUS: 4,1% vs 12,4%, *p=0,01*

Results

Comparison of different diagnostic strategies incorporating Wells score, d-dimer measurement and LUS in 141 patients with pleuritic chest pain and available d-dimer from Reissig 2001 and Nazerian 2017 study

	Wells score ≤4 and negative d-dimer	Wells score ≤4 and negative LUS	Wells score ≤4 and negative LUS in the most painful area
Failure rate^ % (95% CI)	6.7 (1.9-16.2)	3.7 (0.8-10.6)	4.9 (1.36-12.2)
Efficiency+ % (95% CI)	42.5 (34.3-51.2)	56.7 (48.1-65)	57.4 (48.8-65.7)
Sensitivity % (95% CI)	90.7 (77.9-97.4)	93 (80.9-98.5)	90.7 (77.9-97.4)
Specificity % (95% CI)	57.1 (46.7-67.1)	78.6 (69.1-86.2)	78.6 (69.1-86.2)
PPV % (95% CI)	48.1 (42-54.3)	65.6 (55.4-73.7)	65 (55.7-73.3)
NPV % (95% CI)	93.3 (84.4-97.3)	96.2 (89.6-98.7)	95.1 (88.3-98)
LR+ (95% CI)	2.12 (1.65-2.71)	4.34 (2.95-6.4)	4.23 (2.86-6.26)
LR- (95% CI)	0.16 (0.06-0.42)	0.09 (0.03-0.27)	0.12 (0.05-0.3)

LUS= Lung ultrasound; PPV= Positive predictive value; NPV= Negative predictive value; 95% CI= 95% confidence interval.
^ Calculated as the number of patients within the group with a final diagnosis of PE divided by all patients in the same group
+ Calculated as the number of patients within the group divided by all included patients

- Failure rate of Wells + LUS vs Wells + d-dimer: 3,7% vs 6,7%, *p= 0,42*

- Sn of Wells + LUS vs Wells + d-dimer: 93% vs 90%, *p=1*

- Sp of Wells + LUS vs Wells + d-dimer: 78,6% vs 57,1%, *p<0,001*

- Failure rate of Wells + single scan LUS vs Wells +d-dimer: 4,9% vs 6,7%, *p=0,01*

- Sn of Wells + single scan LUS vs Wells +d-dimer: 90,7% vs 90,7%, *p=1*

- Sp of Wells + single scan LUS vs Wells +d-dimer: 78,6% vs 57,4%, *p< 0,001*

Limitations

- The main aim of our study does not coincide with the endpoint of the original studies retrospectively analyzed and included in our investigation
- We cannot exclude that application of LUS by physicians of a lower skill level may result in different accuracy and safety

Conclusions

- LUS searching for pulmonary infarction is a highly sensitive diagnostic tool for pulmonary embolism
- This result does not change when LUS is performed on the whole chest or limited to a single scan in the most painful area
- In patient with pleuritic chest pain, Wells score+LUS performed on the whole chest or limited to a single scan in the most painful chest area is more efficient for ruling out PE compared to Wells score + d-dimer

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