CODEN [USA]: IAJPBB ISSN: 2349-7750

INDO AMERICAN JOURNAL OF
PHARMACEUTICAL SCIENCES

http://doi.org/10.5281/zenodo.2545644

Available online at: http://www.iajps.com *Research Article*

VALUE OF LUNG ULTRASONOGRAPHY FOR THE DIAGNOSIS OF ACUTE PNEUMONIA IN EMERGENCY DEPARTMENT, MULTICENTER STUDY IN MEDINA, SAUDI ARABIA

[1] Dr. Omar Mohammed Alawaji, [2]Dr. Dhiaa Khalid Yones, [3] Dr. Malik Abdulrahman Almalki, [4]Dr. Rashid Abasher Babiker, [5] Dr. Mohamed Fawzi Awadallah

[1]Medical Intern at Taibah University in Medina, Saudi Arabia
[2]Medical Intern at Taibah University in Medina, Saudi Arabia
[3]Medical Intern at Taibah University in Medina, Saudi Arabia
[4]Nephrology Registrar at King Fahad Hospital in Medina, Saudi Arabia
[5]Department of chest faculty of medicine at AL-Azhar university Damietta, Egypt and Respiratory Therapy department. Faculty of medical science and rehabilitation at Taibah university

Abstract:
Objective: to evaluate the usefulness and accuracy of Lung ultrasound (LUS) in the diagnosis of pneumonia in Emergency Department.Method: The study was performed at King Fahad Hospital and Ohud Hospital in Medina, Saudi Arabia. This study included adult patients of both genders (more than 18 years), who suspected to have pneumonia based on the presence of clinical features and physical examination, both of community and hospital-acquired pneumonia was included in this study. Lung ultrasound was performed for patients with suspected pneumonia as soon as possible after their arrival at the Emergency Department and before CXR. Later we evaluate all patients until discharge, comparing the ultrasound results with the final diagnosis made by physicians based on radiological examinations CXR or CT, markers of inflammation and microbiology.Results: This study included 65 adult patients; most of them 72.3% were males. 100% of the cases were detected by CT scan. While, 88% almost of the cases were detected by Lung ultrasound. And about 77% of the cases were detected by chest X-ray. Lung ultrasound findings showed that 84% of cases had dynamic air bronchogram, 44.1% had fluid bronchogram, and 64.1% had interstitial pattern.Conclusion: Lung ultrasound is a safe and accurate option to diagnose suspected pneumonia cases and is more accurate than chest X-ray and allows for radiation-free follow-up of patients.

Keywords; *World health organization, computed tomography, lung ultrasound, chest X-ray.*

Corresponding author:
Dr. Omar Mohammed Alawaji,
Medical Intern at Taibah University
Medina, Saudi Arabia
Contact number : 00966544334833
E-mail address : u.a.alawaji@hotmail.com

QR code

Please cite this article in press Omar Mohammed Alawaji o et al., ***Value of Lung Ultrasonography for the Diagnosis of Acute Pneumonia in Emergency Department, Multicenter Study in Medina, Saudi Arabia.,*** *Indo Am. J. P. Sci, 2019; 06(01).*

INTRODUCTION:

Pneumonia is one of the highest reasons for hospital admissions and considered the most common causes of death in the world (1). In study was done at western region of Saudi Arabia showed that pneumonia is the most common infectious disease with prevalence of 18.8% (2). Also, WHO stated that lower respiratory tract infection is the leading cause of infectious disease related mortality worldwide and the top death reason in low-income countries (3)

The diagnosis of pneumonia is not that easy because of the different scenarios that the patients come with (4,5). Chest X-ray is using today for the diagnosis of pneumonia and worldly agreeable but even though in the bed riding patients or those who not easy to deal with have a lot of weak results. Also, the sensitively that showing for chest X-ray in the studies not as good to make it the diagnostic tool (6). As well as chest X-ray is only 75% accurate comparing to computed tomography (CT) in the diagnosis of pneumonia (7,8) , and with CT which considered the gold standard for the diagnosis of pneumonia the radiation exposure, the time, the cost, the high-level of ventilatory support, and the availability is a set-back for it (9).

The major advantages of lung ultrasound (LUS), particularly over radiographic techniques, are the absence of ionizing radiation, the availability, its speed of acquisition, and the fact that it is relatively unaffected by the patient's cooperation, that may limit her/his breath-hold capability (10,11,12). Lung sonography is more accurate in multiple lung findings as in consolidation and effusion compared to portable CXR (13). Multiple studies state that LUS is a diagnostic in pneumonia (14). Other studies proved the importance of LUS in diagnosis of pneumonia, despite 8% of pneumonia finding were not detectable by LUS for structures causes (15). Other studies stated that it can be used only as complementary to other diagnostic tests (16). To date, guidelines is still too conservative to introduce LUS as an alternative to chest X-ray (CXR) and chest CT for rapid diagnosis of pneumonia (17,18,19)

Objectives :The aim of the current study is to evaluate the usefulness and accuracy of LUS in the diagnosis of Pneumonia.

METHODOLOGY:

Based on the nature of the study, and the objectives sought to be achieved, and the data to be obtained to study the Lung ultrasound performed in patients with suspected pneumonia as soon as their arrival at the ED and before CXR. Later we evaluate all patients until discharge, comparing the ultrasound results with the final diagnosis made by physicians based on radiological examinations CXR or CT, markers of inflammation and microbiology, the study used descriptive analytical approach which is based on the study of the phenomenon, as it is in reality, and contribute to describe it accurately as it illustrates its characteristics through information gathering, analysis and interpretation, and then apply the results in the light.

Population & sample of the study

The study population consists of all eligible patients who was admitted to the Emergency Department suspected to have pneumonia based on the presence of clinical features (e.g., cough, fever, sputum production, and pleuritic chest pain, dyspnea) and physical examination to detect rales or bronchial breath sounds. The number of patients who cooperated with the study 65 patients, and so we have a random study sample composed of 65 Observations, 72.3% of them were male, and 27.7% were female.

Setting

The study performed at King Fahad Hospital and many Private Hospitals in Medina, Saudi Arabia.

Data collection methods:

Lung ultrasound performed in patients with suspected pneumonia as soon as their arrival at the ED and before CXR. Later we evaluate all patients until discharge, comparing the ultrasound results with the final diagnosis made by physicians based on radiological examinations CXR or CT, markers of inflammation and microbiology.

Mechanisms to assure the quality of the study:

Ultra sound findings obtained by well-trained radiologists who experience in lung ultrasound.

Instrumental examination

A convex abdominal (3.5 MHz) probe used. Thoracic US performed using a technique of grid lines that carried out from top to bottom. Fields located between the para sternal (PSL) and the anterior axillary line (AAL) for the anterior fields (I), between the anterior (AAL) and posterior axillary line(PAL)for the axillary fields(II)and between the PAL and para vertebral line (PVL) for the study of the posterior fields (III) (20).

Segmental or Lobar Pneumonia; when the pleural line is no longer distinguishable but appears broken and replaced by an authentic echo-texture of parenchyma analogous to hepatic tissue, it is consistent with segmental or lobar pneumonia. This

image contains air bronchograms (hyperechoic) or fluid bronchograms (anechoic), which are mobile with the respiratory movements (20).

Interstitial Pneumonia; with interstitial pneumonia, the pleural line is always visible, but presents a shredded aspect with many B lines originating from the pleural line and spreading down to the edge of the screen. They are bottomless because they are visible regardless of the depth. They are dynamic and synchronous with the respiratory movements. Visualizing more than three B lines per field in a longitudinal plane between two ribs is considered pathological (20).

Statistical methods

The statistical analysis program (SPSS v.22) used in the study in data entry and analysis, with the use of necessary statistical methods to achieve the objectives of the study, namely, frequencies, percentages, graphs, and chi-squared test.

RESULTS:

Table (1) shows that the mean age of participants is 59.31 with a standard deviation of 17.86. The vast majority of them were males, while 27.7% females. As for their distribution according to the smoking history, we note that 35.4% are mild smokers, 21.5% are moderately smokers, and 6.2% are sever smokers, while 36.89% are non-smokers

Table (1): shows the participants distribution according to age, gender, and smoking history.

Age	Mean ± Std. Deviation	59.31 ± 17.86		
		Frequency	**Percent**	**P-value**
Gender	Male	47	72.3	.000
	Female	18	27.7	
Total		**65**	**100.0**	
Smoking history	Mild	23	35.4	.001
	Moderate	14	21.5	
	Sever	4	6.2	
	Non-smoker	24	36.9	
Total		**65**	**100.0**	

Chest X-ray findings

The following table shows the participants' distribution according to chest X-ray findings, the vast majority of them had a positive diagnosis of chest x-ray, while 23.1% had a negative diagnosis of chest x-ray findings.

Table (2): shows the participants distribution according to chest X-ray findings.

	Frequency	**Percent**	**P-value**
Positive	50	76.9	.000
Negative	15	23.1	
Total	**65**	**100.0**	

Clinical features including

The following table shows the participants' distribution according to clinical features, where we notes that: 92.3% were coughing, 54.2% had pleuritic pain, 78.1% had sputum production, 79% had fever, 90.6% had dyspnea, 93.1% had rales, and 67.2% had bronchial breath sounds.

Table (3): shows the participants' distribution according to clinical features.

	Yes # (%)	**No # (%)**	**P-value**
Cough	60 (92.3)	5 (7.7)	.000
Pleuritic pain	32 (54.2)	27 (45.8)	.515
Sputum production	50 (78.1)	14 (21.9)	.000
Fever	49 (79.0)	13 (21.0)	.000
Dyspnea	58 (90.6)	6 (9.4)	.000
Rales	54 (93.1)	4 (6.9)	.000
Bronchial breath sounds	39 (67.2)	19 (32.8)	.009

The following table shows the heart rate and respiratory rate, where we note that the mean heart rate of participants is 94.02 (beat per minute) with a standard deviation of 15.24, and mean respiratory rate of participants is 24.7 (beat per minute) with a standard deviation of 5.26.

Table (4): shows the heart rate and respiratory rate.

	Mean ± Std. Deviation
Heart rate (Beat per minute)	94.02 ± 15.24
Respiratory rate (Beat per minute)	24.70 ± 5.26

Ultrasound findings

The following table shows the participants' distribution according to alveolar consolidation, the vast majority of them had alveolar consolidation, while 12.3% had no alveolar consolidation.

Table (5): shows the participants' distribution according to alveolar consolidation.

Alveolar consolidation:	**Frequency**	**Percent**	**P-value**
Present	57	87.7	.000
Absent	8	12.3	
Total	**65**	**100.0**	

The following diagram shows the location of alveolar consolidation, Where we note that 26 patients had alveolar consolidation in the right lung, 12 patients had alveolar consolidation in the left lung, 27 patients had alveolar consolidation in the right lung and left, while 6 patients had alveolar consolidation retro cardiac.

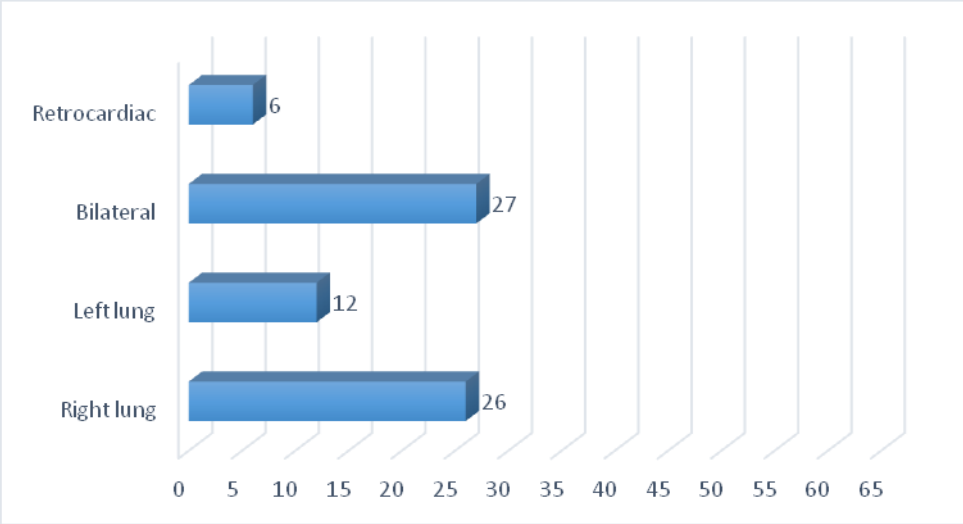

Diagram (1): shows the location of alveolar consolidation in patients.

The following table shows the participants' distribution according to dynamic air bronchogram, fluid bronchogram, and interstitial pattern, where we notes that: 84% had dynamic air bronchogram, 44.1% had fluid bronchogram, and 64.1% had interstitial pattern.

Table(6): shows the participants' distribution according to dynamic air bronchogram, fluid bronchogram, and interstitial pattern.

	Present # (%)	**Absent # (%)**	**P-value**
Dynamic air bronchogram	42 (84.0)	8 (16.0)	.000
Fluid bronchogram	15 (44.1)	19 (55.9)	.493
Interstitial pattern	25 (64.1)	14 (35.9)	.078

The following diagram shows the location of dynamic air bronchogram, fluid bronchogram, and interstitial pattern in patients.

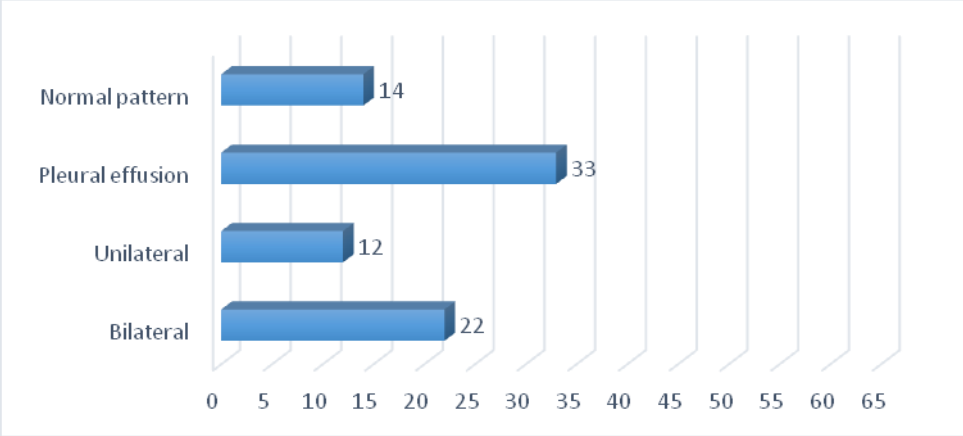

Diagram (2): shows the location of dynamic air bronchogram, fluid bronchogram, and interstitial pattern in patients.

CT findings (if done)

The following diagram shows the CT findings for patients who went throw CT scan. All patients had abnormal results.

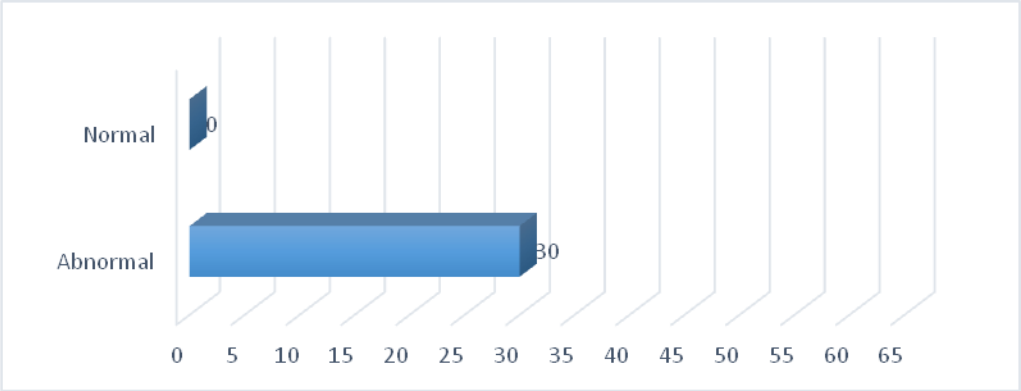

Diagram (3): shows CT findings.

Table (7): The relationship between chest X-ray findings and Ultrasound findings

Ultrasound findings		**New pulmonary infiltration on X-ray**		**P-value**
		Positive	Negative	
Alveolar consolidation:	Present	48	9	.000**
	Absent	2	6	
Dynamic air bronchogram:	Present	32	10	.942
	Absent	6	2	
Fluid bronchogram	Present	10	5	.914
	Absent	13	6	
Interstitial pattern	Present	19	6	.754
	Absent	10	4	

****Significant at the 0.01 level**

We conclude from the previous table that there is a relationship between the chest X-ray findings and Alveolar consolidation, but there is no relationship between the chest X-ray findings and (Dynamic air bronchogram, fluid bronchogram, and lnterstitial pattern).

Table (8): The relationship between chest X-ray findings and clinical features.

Clinical features		**New pulmonary infiltration on X-ray**		**P-value**
		Positive	Negative	
Cough	Yes	46	14	.865
	No	4	1	
Pleuritic pain	Yes	26	6	.508
	No	20	7	
Sputum production	Yes	42	9	.047*
	No	8	6	
Fever	Yes	40	9	.123
	No	8	5	
Dyspnea	Yes	45	13	.746
	No	5	1	
Rales	Yes	42	12	.290
	No	4	0	
Bronchial breath sounds	Yes	35	4	.000**
	No	8	11	

****Significant at the 0.01 level *Significant at the 0.05 level**

We conclude from the previous table that there is a relationship between the chest X-ray findings and (sputum production, bronchial breath sounds), but there is no relationship between the chest X-ray findings and (cough, pleuritic pain, fever, dyspnea, and rales).

Table (9): The relationship between smoking history and Ultrasound findings

Ultrasound findings		**Smoking history**				**P-value**
		Mild	Moderate	Sever	Non-smoker	
Alveolar consolidation:	Present	17	13	4	23	.093
	Absent	6	1	0	1	
Dynamic air bronchogram:	Present	14	10	2	16	.731
	Absent	4	1	0	3	
Fluid bronchogram	Present	8	2	0	5	.839
	Absent	9	4	0	6	
Interstitial pattern	Present	13	5	0	7	.274
	Absent	6	2	2	4	

We conclude from the previous table that there is no relationship between Smoking history and Ultrasound findings.

Table (10): The relationship between smoking history and clinical features.

Clinical features		**Smoking history**				**P-value**
		mild	moderate	sever	Non-smoker	
Cough	Yes	23	14	4	19	.026*
	No	0	0	0	5	
Pleuritic pain	Yes	10	8	3	11	.318
	No	12	5	0	10	
Sputum production	Yes	18	11	3	19	.998
	No	5	3	1	5	
Fever	Yes	17	9	3	20	.775
	No	4	4	1	4	
Dyspnea	Yes	22	12	4	20	.602
	No	1	2	0	3	
Rales	Yes	17	13	4	20	.447
	No	1	0	0	3	
Bronchial breath sounds	Yes	14	7	2	16	.506
	No	9	5	1	4	

***Significant at the 0.05 level**

We conclude from the previous table that there is a relationship between smoking history and cough, but there is no relationship between smoking history and (pleuritic pain, sputum production, fever, dyspnea, ralesm and bronchial breath sounds).

DISCUSSION:

Early diagnosis and management of pneumonia are important factors in short- and long-term health outcomes. Clinical examination is highly sensitive but lacks specificity and results in diagnosis that contributes to antibiotics excessive use (21). CXR is recommended for routine use for patients with suspected pneumonia, but CXR use is limited in emergency settings (22), CXR also is less reliable in complicated pneumonia (21). While, CT scan is known to be the gold standard. But the use of CT scan has been discouraged due to high cost, high radiation and the need for sedation in young children (21,23). LUS has been well-recognized as a valuable bedside tool of diagnosing pulmonary diseases and providing a user-friendly, noninvasive, reliable, and inexpensive examination (23,24). Therefore, this study aimed to evaluate the usefulness and accuracy

of LUS in the diagnosis of pneumonia in Emergency Department. The current study included adult patients of both genders (more than 18 years), who suspected to have pneumonia based on the presence of clinical features and physical examination, both of community and hospital-acquired pneumonia was included in this study.

In the present study CT findings showed that all patients patients who underwent CT scans had abnormal results. This is expected given that CT is the gold standard for diagnosis of pneumonia (25). Chest X-ray findings of our study showed that 77% had a positive diagnosis, while LUS findings showed that about 88% had alveolar consolidation. Based on this, according to that , we can say that the LUS scan was more accurate than the Chest X-rays and closer to the CT results. In a similar study among adult patients, Parlamento et al. found that 96.9% had positive lung US while 75% had positive CXR (26). Also Tirdia et al. found that the detection of pneumonia among children using LUS was better 97.84% than with chest radiography 90.64% (21). In chest radiography there is wide inter- and intra-observer variability when interpreting results, as well as there is differing radiologic manifestations of pneumonia, and possible lack of sensitivity and specificity. So, chest radiography cannot be considered a diagnostic gold standard of pneumonia (27).

Ellington et al. concluded from their study among children that Lung ultrasound had high diagnostic accuracy for the diagnosis of radiographically-confirmed pneumonia (28). While, Both of Llamas-Álvarez et al. (29) and Long et al. (30) found that Lung ultrasonography can help to diagnose adult pneumonia with high accuracy in adults. Xia et al. performed a systematic review to assess the diagnosis accuracy of LUS for pneumonia in adults, and found that sensitivity of LUS for pneumonia in adult was 90.4% and specific was 88.4% (24). Chavez et al. also, performed a meta-analysis to summarize existing evidence of the diagnostic accuracy of LUS for pneumonia in adults, and found that LUS had a high sensitivity (94%) and specificity (96%) for the diagnosis of pneumonia in adults (31). Urbankowska et al. conducted a study to evaluate the usefulness and accuracy of LUS in the diagnosis and monitoring of childhood Community-Acquired Pneumonia, and found that sensitivity of 93.4%, specificity of 100%, positive predictive value of 100%, negative predictive value of 85.7% and accuracy of 95.3% (32). While, a recent meta-analysis in by Pereda et al. conducted to summarize evidence on the diagnostic accuracy of LUS for childhood pneumonia, and showed overall pooled sensitivity of 96% and specificity of 93% (33). Based on that, we can say that LUS is an effective and accurate way to detect pneumonia. Medford and reported that LUS is a simple way to avoid using radiation, and it can explore some of certain findings that are not clear on chest radiography (33).

In our study LUS was able to detect the place of alveolar consolidation, as 26 patients had alveolar consolidation in the right lung, 12 patients had alveolar consolidation in the left lung, 27 patients had alveolar consolidation in the right lung and left, while 6 patients had alveolar consolidation retro cardiac.

The most significant parenchymal criterion of pneumonia is the positive air bronchogram within an echopoor area (34). Lichtenstein and colleagues suggested that dynamic air bronchogram is indicative of pneumonia and distinguishing it from resorptive atelectasis (35). In our study 84% had dynamic air bronchogram. Previous studies showed that air bronchogram may be found in about 70-97% of cases (36-39). while among pleural criteria basal effusion was the most frequent detection of pneumonia (34), which found in about 34-61% cases (36-40). In our study 44.1% had fluid bronchogram, while 64.1% had interstitial pattern.

CONCLUSION:

Our study shows that LUS is a safe and accurate option to diagnose suspected pneumonia cases and is more accurate than CXR and allows for radiation-free follow-up of patients. The use of LUS should be encouraged not only as a correct diagnostic alternative but as a necessary ethical choice.

ACKNOWLEDGEMENT:

We send our huge thanks to King Fahd Hospital in medina city, and Dr. Abeer Alharbi, as she was our biggest helper and supportive, and it is rare to never to found someone like her, we hope for her and her family the best life in their feature and may Allah bless her.

REFERENCES:

1. Almirall J, Bolibar I, Vidal J, Sauca G, Coll P, Niklasson B et al (2000) Epi-demiology of community-acquired pneumonia in adults: a population-based study. Eur Respir J 15(4):757–763
2. Aisha A. Alghamdi, FACP, Omer S. Alamoudi, FRCP, Tawfik M. Ghabrah, PhD, and Mohammed A. Al-Kassimi, FRCP(UK) (2009) Pattern of Infectious Diseases in the Western Region of Saudi Arabia; A Study of 495

Hospitalized Patients.
3.Wunderink RG, Waterer GW. Clinical practice. Community-acquired pneumonia. N Engl J Med 2014;370:543-51.
4. Graffelman AW, le Cessie S, Knuistingh Neven A, Wilemssen FEJA, Zonderland HM, van den Broek PJ. Can history and exam alone reliably predict pneumonia? J Fam Pract. 2007;56(6):465–70.
5. Emerman CL, Dawson N, Speroff T, Siciliano C, Effron D, Rashad F, et al. Comparison of physician
judgment and decision aids for ordering chest radiographs for pneumonia in outpatients. Ann Emerg Med. 1991;20(11):1215–9.
6. Hagaman JT, Rouan GW, Shipley RT, Panos RJ. Admission chest radiograph lacks sensitivity in the diagnosis of community-acquired pneumonia. Am J Med Sci. 2009;337(4):236–40.
7. Syrjala H, Broas M, Suramo I, et al. High-resolution computed tomography for the diagnosis of community-acquired pneumonia. Clin Infect Dis 1998; 27:358–363.
8. Claessens YE, Debray MP, Tubach F, et al. Early chest computed tomography scan to assist diagnosis and guide treatment decision for suspected community-acquired pneumonia. Am J Respir Crit Care Med 2015; 192:974–982.
9. Brenner DJ , Hall EJ . Computed tomography—an increasing source of radiation exposure . N Engl J Med . 2007 ; 357 (22): 2277 - 2284 .
10. Lichtenstein D, Mézière G, Biderman P, Gepner A, Barré O. The comet-tail artifact. An ultrasound sign of alveolar-interstitial syndrome. Am J Respir Crit Care Med 1997; 156:1640 6.
11. Lichtenstein DA. Ultrasound in the management of thoracic disease. Crit Care Med 2007;35:S250–61.
12. Copetti R, Soldati G, Copetti P. Chest sonography: a useful tool to differentiate acute cardiogenic pulmonary edema from acute respiratory distress syndrome. Cardiovasc Ultrasound 2008;6:16.
13. Lichtenstein D, Goldstein I, Mourgeon E, Cluzel P, Grenier P, Rouby J-J (2004) Comparative diagnostic performances of auscultation, chest radiography, and lung ultrasonography in acute respiratory distress syndrome. Anesthesiology 100(1):9–15
14. Laursen CB, Sloth E, Lassen AT, et al. Point-of-care ultrasonography in patients admitted with respiratory symptoms: a single-blind, randomized controlled trial. Lancet Resp Med 2014;2:638–46.
15. Reissig A, Copetti R, Mathis G, et al. Lung ultrasound in the diagnosis and follow-up of community-acquired pneumonia. A prospective, multicenter, diagnostic accuracy study. Chest 2012;142:965–72.
16. Sperandeo M, Carnevale V, Muscarella S, et al. Clinical application of transthoracic ultrasonography in inpatients with pneumonia. Eur J Clin Invest 2011;41:1–7.
17. Eccles S, Pincus C, Higgins B, et al. Diagnosis and management of community and hospital acquired pneumonia in adults: summary of NICE guidance. BMJ 2014;349:g6722.
18. American Thoracic Society; Infectious Diseases Society of America. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare associated pneumonia. Am J Respir Crit Care Med 2005;171:388-416.
19. Kalil AC, Metersky ML, Klompas M, et al. Management of Adults With Hospital-acquired and Ventilator-associated Pneumonia: 2016 Clinical Practice Guidelines by the Infectious Diseases Society of America and the American Thoracic Society. Clin Infect Dis 2016;63:e61-e111.
20. Lung Ultrasound Will Soon Replace Chest Radiography in the Diagnosis of Acute Community-Acquired Pneumonia
21. Tirdia, Prahlad R., et al. "Accuracy of lung ultrasonography in diagnosis of community acquired pneumonia in hospitalized children as compared to chest x-ray." *International Journal of Contemporary Pediatrics* 3.3 (2016): 1026-1031.
22.Corradi, Francesco, et al. "Quantitative analysis of lung ultrasonography for the detection of community-acquired pneumonia: a pilot study." *BioMed research international* 2015 (2015).
23.Pereda, Maria A., et al. "Lung ultrasound for the diagnosis of pneumonia in children: a meta-analysis." *Pediatrics* 135.4 (2015): 714-722.
24.Xia, Yang, et al. "Effectiveness of lung ultrasonography for diagnosis of pneumonia in adults: a systematic review and meta-analysis." *Journal of thoracic disease* 8.10 (2016): 2822.
25.Brenner DJ , Hall EJ . Computed tomography—an increasing source of radiation exposure . N Engl J Med . 2007 ; 357 (22): 2277 - 2284 .
26.Parlamento, Stefano, Roberto Copetti, and Stefano Di Bartolomeo. "Evaluation of lung ultrasound for the diagnosis of pneumonia in the ED." *The American journal of emergency medicine* 27.4 (2009): 379-384.
27.Stadler, J. A., Andronikou, S., & Zar, H. J. (2017). Lung ultrasound for the diagnosis of community-

acquired pneumonia in children. *Pediatric Radiology*, *47*(11), 1412-1419.
28.Ellington, Laura E., et al. "Lung ultrasound as a diagnostic tool for radiographically-confirmed pneumonia in low resource settings." *Respiratory medicine* 128 (2017): 57-64.
29.Llamas-Álvarez, Ana M., Eva M. Tenza-Lozano, and Jaime Latour-Pérez. "Accuracy of lung ultrasonography in the diagnosis of pneumonia in adults: systematic review and meta-analysis." *Chest* 151.2 (2017): 374-382.
30.Long, Ling, et al. "Lung ultrasound for the diagnosis of pneumonia in adults: a meta-analysis." *Medicine* 96.3 (2017).
31.Chavez, M. A., Shams, N., Ellington, L. E., Naithani, N., Gilman, R. H., Steinhoff, M. C., ... & Checkley, W. (2014). Lung ultrasound for the diagnosis of pneumonia in adults: a systematic review and meta-analysis. *Respiratory research*, *15*(1), 50.
32.Urbankowska, E., Krenke, K., Drobczyński, Ł., Korczyński, P., Urbankowski, T., Krawiec, M., ... & Kulus, M. (2015). Lung ultrasound in the diagnosis and monitoring of community acquired pneumonia in children. *Respiratory medicine*, *109*(9), 1207-1212.
33.Medford, A. R. L., and J. J. Entwisle. "Indications for thoracic ultrasound in chest medicine: an observational study." *Postgraduate medical journal* 86.1011 (2010): 8-11.
34.Reissig, Angelika, et al. "Lung ultrasound in the diagnosis and follow-up of community-acquired pneumonia: a prospective, multicenter, diagnostic accuracy study." *Chest* 142.4 (2012): 965-972.
35.Lichtenstein, Daniel, Gilbert Mezière, and Julien Seitz. "The dynamic air bronchogram: a lung ultrasound sign of alveolar consolidation ruling out atelectasis." *Chest* 135.6 (2009): 1421-1425.
36.Reissig, Angelika, et al. "Lung ultrasound in the diagnosis and follow-up of community-acquired pneumonia: a prospective, multicenter, diagnostic accuracy study." *Chest* 142.4 (2012): 965-972.
37.Reissig, Angelika, and Claus Kroegel. "Sonographic diagnosis and follow-up of pneumonia: a prospective study." *Respiration*74.5 (2007): 537-547.
38.Gehmacher, O., et al. "Ultrasound imaging of pneumonia." *Ultrasound in medicine & biology* 21.9 (1995): 1119-1122.
39.Sperandeo, Marco, et al. "Clinical application of transthoracic ultrasonography in inpatients with pneumonia." *European journal of clinical investigation* 41.1 (2011): 1-7.
40.Parlamento, Stefano, Roberto Copetti, and Stefano Di Bartolomeo. "Evaluation of lung ultrasound for the diagnosis of pneumonia in the ED." *The American journal of emergency medicine* 27.4 (2009): 379-384.