

## Lung ultrasound for the diagnosis of pneumonia in adults

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### Abstract

**Objective:** To investigate the value of chest ultrasound in the diagnosis of pneumonia in adults.

**Methods:** The prospective observational cohort study was conducted at Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Istanbul, Turkey, from December 1, 2015, to March 1, 2016, and comprised suspected pneumonia patients aged >18 years. Sonographic pneumonia was defined as lung consolidation with air bronchograms. Treating clinicians were blinded to lung ultrasound results. All patients who were advised to undergo thoracic computerised tomography after physical examination were subjected to posteroanterior chest X-ray before the scan. Patients in whom pneumonia was detected in the scan underwent thorax ultrasonography according to Bedside Lung Ultrasound in Emergency protocol. Follow-up was done with medical record review to obtain the final diagnosis and antibiotic usage. Data was analysed using SPSS 22.

**Results:** Of the 125 patients, 61 (48.8%) were male. The overall mean age was 73.9±14.6 years. In 97 (77.6%) patients, pneumominal infiltration was detected by thorax ultrasound, and in 57 (45.6%) the infiltration was detected with chest X-ray.

**Conclusion:** Thorax ultrasound was found to be a helpful diagnostic method when performed according to the Bedside Lung Ultrasound in Emergency protocol.

**Keywords:** Thorax ultrasound, Pneumonia, Emergency department. (JPMA 70: 989; 2020)

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### Introduction

Pneumonia is an important global health problem with high morbidity and mortality rates.<sup>1</sup> In Turkey, lower respiratory tract infections (LRTIs) are placed 5th with a mortality rate of 4.2%.<sup>2</sup> Pneumonia can be diagnosed via physical examination findings alone, but should be supplemented with additional diagnostic tests.<sup>3</sup> In patients with suspected pneumonia, posteroanterior (PA) chest radiography is the first routine examination. Because of the presence of radiation, it is not used in pregnant women and children.<sup>4,5</sup> Due to the patient's position, time-loss, interpretation differences between clinicians, ultrasonography (USG) is not used routinely. Thorax computerised tomography (CT) is the best diagnostic method, but it has disadvantages such as high cost, high dose radiation, inaccessibility, difficult transfer of critical patients and delay in diagnosis.<sup>6</sup> Because of this reason, lung ultrasonography (LUSG) stands out as a useful technique with advantages such as early bedside diagnosis, rapid and easy application, radiation-free, non-invasive and low-cost.<sup>7</sup> Studies have shown that it has high specificity and sensitivity, especially in paediatric patients, and detects pneumonia 12-25% better than chest X-ray (CXR).<sup>8</sup> There is limited data about the value of

USG in adult patients with suspected pneumonia and there have been few studies on adult emergency services.<sup>9</sup> The current study was planned to investigate the value of thoracic USG in the diagnosis of pneumonia in adult patients in an emergency department (ED) setting.

### Patients and Methods

The prospective observational cohort study was conducted from December 1, 2015, to March 1, 2016, at the ED of Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Istanbul, Turkey, a tertiary adult facility. After approval institutional ethics review committee, the study sample was raised by including suspected pneumonia patients aged 18 years or above who had at least 3 of the following symptoms: fever, coughing, dyspnoea, sputum, pleuritic pain. Also, the patients agreed to undergo CT scan and consented to participate in the study. Those excluded were pregnant women, those aged <18 year, patients with emergent intervention indications and those who refused to undergo CT scan or did not consent to participate in the study.

After taking informed consent from the subjects, each patient's vital signs, physical examination findings, USG, chest X-ray and CT results were evaluated. In order to ensure standardization, the physicians who performed USG first received 'Basic and Advanced Ultrasound' training organised by the Emergency Medicine Association of Turkey. LUSG was performed according to

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Bedside Lung Ultrasound in Emergency (BLUE) protocol using 10MHz superficial probe.<sup>10</sup> Pneumonic infiltrations were characterised by irregular, serrated and somewhat blurred margins or dynamic depending on breathing movement, distinguishing them from obturation atelectasis. The fluid bronchogram was marked by anechoic/hypo-echoic branched tubular structures in relation to the bronchial tree.<sup>9</sup>

Follow-up data was obtained from the patient's medical record. All patients were consulting chest diseases specialists. Antibiotic treatment was started in all patients. For further analysis, we identified patients as positive for pneumonia if they had either a positive chest radiograph or a final clinical diagnosis and were treated with antibiotics.

Data was analysed using SPSS 22 and MedCalc version 17.9.7. Normality of data was tested using Kolmogorov-Smirnov test. Continuous variables were expressed as mean±standard deviation (SD) for normally distributed data, or median and interquartile range (IQR) for non-normally distributed data. Categorical variables were expressed as frequencies and percentages. Differences in continuous variables were assessed using Mann-Whitney U test and categorical variables were compared using Pearson's chi-square test. P<0.05 was considered statistically significant.

## Results

During the study period, 57,972 patients were admitted to the ED. Of them, 1,225(2.1%) patients were suspected with pneumonia, and 410(33.5%) of these patients were

**Table-1:** Lung ultrasonography and chest radiography (CXR) characteristics of the patients.

Lung Localization	LUSG Infiltration n (%)	Sensitivity % (%95 C.I)	Specificity % (%95 C.I)	Prevalence (%95 C.I)	NPV (%95 C.I)	PPV % (%95 C.I)
Right Upper Zone	1 (0.8)	33.3 (0.84-90)	100 (91.96)	6.38 (1.34-17.54)	95.7 (90.81-98)	100
Right Middle Zone	19 (15.2)	90.5 (69.92-98.82)	100 (91.96)	32.3 (21.23-45.06)	95.7 (85.48-98.8)	100
Right Side Zone	42 (33.6)	73.7 (60.34-84.46)	100 (91.96)	56.4 (46.2-66.28)	74.6 (64.51-81.91)	100
Left Upper Zone	1 (0.8)	100 (2.5-100)	100 (92.45)	2.1 (6.05-11.07)	100 (100)	100
Left Middle Zone	23 (18.4)	62.9 (44.92-78.53)	100 (92.45)	42.7 (31.82-54.1)	78.3 (70.15-84.76)	100
Left Side Zone	21 (216.8)	45 (29.26-61.51)	100 (92.45)	46 (35.23-57)	68.1 (61.75-73.87)	100

  

	CXR Infiltration n (%)	Sensitivity % (%95 C.I)	Specificity % (%95 C.I)	Prevalence % (%95 C.I)	NPV % (%95 C.I)	PPV % (%95 C.I)
Right Upper Zone	1 (0.8)	33.3 (0.84-90.5)	100 (91.96)	6.4 (13.4-17.54)	95.7 (90.81-98)	100
Right Middle Zone	11 (8.8)	52.4 (32.36-59.34)	100 (91.96)	32.3 (46.2-66.28)	91.5 (52.81-64.29)	100
Right Side Zone	26 (20.8)	45.6 (29.78-74.29)	100 (91.96)	56.4 (21.23-45.06)	58.7 (73.52-92.37)	100
Left Upper Zone	1 (0.8)	100 (2.5-100)	100 (92.45)	2.1 (0.05-11.07)	100	100
Left Middle Zone	18 (14.4)	47.2 (30.4-64.51)	100 (92.45)	43.4 (32.53-54.71)	71.2 (64.49-77.11)	100
Left Side Zone	11 (8.8)	27.5 (14.6-43.89)	100 (92.45)	46 (35.23-57)	61.8 (55.25-66.23)	100

LUSG: Lung Ultrasonography, CR: Chest radiography, NPV: Negative Predictive Value, PPV: Positive Predictive Value, CI: Confidence Interval.

**Table-2:** Lung ultrasonography, chest CT and chest X-ray characteristics of the patients.

LUSG Infiltration	Chest X-ray Infiltration		P*	Chest X-ray Sensitivity % (%95 C.I)
	Available n (%)	Not available n (%)		
Available n (%)	52 (91.2)	45 (66.2)	0.001	45.6 (36.67-54.75)
Not available n (%)	5 (17.9)	23 (82.1)		
Chest CT Infiltration	57 (45.6)	68 (54.4)		

  

LUSG Infiltration	Chest CT Infiltration n (%)	LUSG Sensitivity % (%95 C.I)
Available n (%)	97 (77.6)	77.6 (69.28-84.57)
Not available n (%)	28 (22.4)	
Total N	125 (100)	

LUSG: Lung Ultrasonography, CT: Computed tomography, CI: Confidence interval \*Pearson Chi-Square.

diagnosed with pneumonia. The study sample had 125(30.5%) subjects who met the inclusion criteria.

Of the 125 subjects, 61(48.8 %) were male and the overall mean age of the patients was 73.9±14.6 years (range: 23-94 years). The mean systolic blood pressure (SBP) was 123.8±31.4mmHg (range: 80-200mmHg), mean diastolic blood pressure (DBP) was 71.8±17.1mmHg (range: 40-135mmHg), mean pulse per minute was 106.2±18.9/min (range: 57-185/min), and mean respiratory rate was 28.8±3.1/min (range: 18-35/min). Overall, 109(87.2%) patients had fever, 121(96.8%) had coughing, 92(73.6%) had sputum, 107(85.6%) had dyspnoea and 29(23.2%) patients had pleuritic pain. During lung auscultation, rash was observed in 49(39.2%) patients, 41 (32.8%) had ronus, and 109(87.2%) patients had a decrease in the respiratory sounds.

In terms of sensitivity LUSG detected pneumonic infiltration in 97(77.6%) patients, while CXR detected the min 57(45.6%) cases (Tables-2).

## Discussion

Pneumonia is a significant global health issue during the first five decades of life with high morbidity and mortality. Therefore, quick diagnosis and treatment of pneumonia is very important. Although CT scan is the gold standard method in diagnosing pneumonia,<sup>7</sup> LUSG has recently been found to be a highly effective tool in the diagnosis and follow-up of pneumonia in adults as well as in children.<sup>8</sup> Therefore LUSG has become available in paediatric intensive care unit (ICU) and ED services.<sup>11</sup> A study<sup>12</sup> on the value of LUSG in diagnosing pneumonia had 308 patients with suspected pneumonia, another had 30 patients,<sup>4</sup> and one other study<sup>9</sup> had 120 patients. The current study had 125 patients with suspected pneumonia. Considering the studies about the value of LUSG in diagnosing pneumonia, mostly were performed in ICUs, paediatric and chest disease clinics, while the current study was conducted in an adult ED. In a meta-analysis designed to evaluate pneumonia, LUSG was performed before CXR and CT scan. It found LUSG sensitivity in diagnosing pneumonia to be 94% and specificity 96%.<sup>13</sup> In another meta-analysis, the sensitivity and specificity were 95%.<sup>14</sup> In a prospective clinical trial, the sensitivity of LUSG was 98% and specificity 95%.<sup>9</sup> In a prospective study, both hemitoraxes were examined by LUSG and the findings were compared to CXR results and CT scan was performed as the gold standard.<sup>15</sup> The sensitivity of LUSG was reported to be 100% and specificity 89%.<sup>4</sup> In the current study, the sensitivity of LUSG in the right upper zone was 33.3%, specificity 100%; sensitivity in the right middle zone 90.5%, specificity

100%; sensitivity in the right lower zone 73.7%, specificity 100%; sensitivity in the left upper zone 100%, specificity 100%; sensitivity in the left middle zone 62.9%, specificity 100%; and sensitivity in the left lower zone was 45%, with specificity 100%. According to the results obtained when comparing LUSG to lung regions, the sensitivity of LUSG in the right upper zone was 33.3%, specificity 100%; sensitivity in the right middle zone 90.5%, specificity 100%; sensitivity in the right lower zone 73.7%, specificity 100%; sensitivity in the left upper zone 100%, specificity 100%; sensitivity in the left middle zone 62.9%, specificity 100%; and sensitivity in the left lower zone was 45%, with specificity 100%. The highest sensitivity was for the right middle zone and the left upper zone. The lowest sensitivity was for the left lower zone. This may be due to the localisation of heart in this area of chest. In this regard no study was found in literature.

In one study,<sup>9</sup> the sensitivity of CXR to diagnose pneumonia was 67%, specificity 85%. In another study,<sup>16</sup> LUSG sensitivity was 91%, specificity 68%. Another study,<sup>15</sup> reported CXR sensitivity 38%, specificity 89%. LUSG detected more (12-25%) pneumonias than CXR confirmed by chest CT. LUSG is a non-invasive, bedside-available tool used for high-accuracy (sensitivity 93.4%, specificity 97.7%) diagnosis of community-acquired pneumonia.<sup>8</sup> In the current study, CXR sensitivity was 33.3% in the right upper zone, specificity 100%; sensitivity in the right middle zone 52.4%, specificity 100%; sensitivity in the right lower zone 45.6%, specificity 100%; sensitivity in the left upper zone 100%, specificity 100%; sensitivity in the left middle zone 47.2%, specificity 100%; and sensitivity in the left lower zone was 27.5%, with specificity 100%.

## Conclusion

LUSG was found to be a useful technique in detecting pneumonia. It is a beneficial technique that can be performed by ED physicians with high accuracy, high sensitivity and specificity, and allows quick assessment of unstable patients besides being radiation-free.

**Disclaimer:** None.

**Conflict of Interest:** None.

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