Med. J. Cairo Univ., Vol. 87, No. 3, June: 1987-1996, 2019
www.medicaljournalofcairouniversity.net

Lung Ultrasound for Early Diagnosis of Ventilator-Associated Pneumonia

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Abstract

Background: Lung Ultrasound (LUS) has important role in diagnosis of different lung diseases so it can be used in diagnosis and early detection of Ventilator-Associated Pneumonia (VAP).

Aim of Study: Our aim is to evaluate the sensitivity and the specificity of lung ultrasound for early diagnosis of ventilator-associated pneumonia compared to chest X-ray.

Patients and Methods: This study was carried out on 100 patients divided into two Groups (A & B), each one included 50 adult male and female patients with suspected VAP. In Group A (LUS), we searched for lung ultrasound findings as subpleural consolidation, lobar consolidation, and dynamic arborescent/linear air bronchogram while in Group B (CXR), we searched for chest X-ray findings as lung infiltrates and air bronchogram. In both groups, Endotracheal Aspirates (EA) was collected for direct gram stain examination (EAgram) and culture (EAquant). LUS findings were analyzed in scores as the clinical-LUS score (Ventilator-associated Pneumonia Lung Ultrasound Score [VPLUS]) which was calculated as follows: ≥2 areas with subpleural consolidations, 1 point; ≥1 area with dynamic arborescent/linear air bronchogram, 2 points; and purulent EA, 1 point. Positive direct gram stain examination (EAgram) or positive culture (EAquant) which had 2 points were added to VPLUS to be VPLUS EAgram and VPLUS EAquant.

Results: The sensitivity and the specificity of lung ultrasound findings in Group A (LUS) were higher than chest X-ray findings Group B (CXR) as presence of ultrasound signs in Group A (LUS) (lobar/hemilobar consolidations, dynamic air bronchogram, subpleural consolidations) separate or combined gave us sensitivity 97%, lobar or hemilobar consolidations had sensitivity 94%, presence of dynamic air bronchogram or subpleural consolidations gave us sensitivity 94%, VPLUS-EAquant ≥3 gave us sensitivity 94%. The best specificity was found also in Group A as (air bronchogram + subpleural consolidations + positive culture or positive gram stain examination) gave us the highest specificity 100%, combination of (dynamic air bronchogram and subpleural consolidations) gave us high specificity 94%, combination of (lobar/hemilobar consolidations, dynamic air bronchogram and subpleural consolidations) gave us also high specificity 94%, (VPLUS-EAquant ≥4, VPLUS-EAgram ≥4 and VPLUS ≥3) had specificity 94%. On the other hand, signs of chest X-ray in Group B had lower sensitivity and specificity compared to lung ultrasound in Group A as chest X-ray infiltrates gave us sensitivity 53%, specificity 25%, air bronchogram had sensitivity 33%, specificity 40%, presence of (chest X-ray infiltraes, air bronchogram) separate or combined gave us sensitivity 57%, specificity 25%.

Conclusion: The sensitivity and specificity of lung ultrasound were higher than chest xray, so lung ultrasound is better than chest X-ray for early diagnosis of VAP.

Key Words: *Lung ultrasound – Chest X-ray – Ventilator-Associated Pneumonia (VAP).*

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Introduction

VENTILATOR-Associated Pneumonia (VAP) is a common respiratory disease which occurs 48 hours or more on Mechanical Ventilation (MV), associated with increased mortality and morbidity. There are two types of VAP: (A) Early onset VAP which occurs within the first 4 days of mechanical ventilation [1]. (B) Late onset VAP which happens after day 4 and is more frequently due to Multidrug-Resistant pathogens (MDR) [2].

VAP suspected by presence of a new lung infiltrate in chest radiographs after admission, with at least two of the following clinical signs and symptoms: Purulent tracheal secretions, body temperature (≥38.5ºC or ≤36.5ºC), leucocytosis (>11,000 cells/mm^3) or leucopenia (<4,000cells/mm^3), PaO_2 to FiO_2 ratio <300mmHg with no evidence of acute respiratory distress syndrome [3,4].

Diagnosis of VAP includes clinical data, chest xray, culture, gram stain examination and lung ultrasound. Culture from endotracheal tube is the gold standard for diagnosis of VAP. Chest X-ray used for diagnosis of VAP by finding new lung

infiltrates which may bilateral scattered, lobar or hemilobar [5].

Also lung ultrasound used in diagnosis of VAP. Lobar/hemilobar consolidations, sub-pleural consolidations, dynamic air bronchogram are the sonographic signs of VAP [6]. Prevention of VAP can be done by some ways as limiting exposure to mechanical ventilation, preferring non-mechanical ventilation when possible, reducing airways colonization by oral care decontamination using chlorhexidine, or preventing aspiration (e.g. by nursing in the semi-recumbent position, or maintaining a sufficient cuff pressure), daily sedation hold, strict hand hygiene with alcohol especially before managing the airways, prevention of biofilm formation in the lumen of endotracheal tube and around the cuff [7,8].

Treatment involves identifying the causal germs and active antibiotic therapy. Any delay in starting antibiotics in severe sepsis increases mortality, therefore the need for early detection of VAP [9,10]. In this study, we evaluated the role of lung ultrasound for early detection of ventilator-associated pneumonia in comparison to chest X-ray.

Material and Methods

This study was carried out in Tanta University Hospitals at Surgical Intensive Care Unit (SICU) from June 2017 to May 2018 after approval from Institutional Ethical Committee, all data of patients were confidential with secret codes and private file for each patient, also an informed consent was obtained from every patient participating in this study that included 100 patients divided into two Groups (A & B), each one included 50 adult male and female patients with suspected VAP ranged from 18 to 70 years old.

Inclusion criteria:

The study included the patients with suspected VAP. The duration of MV differed from one patient to another and so time of suspicion of VAP. Patients put on MV due to different causes as intra cranial haemorrhage, brain tumor, polytrauma, intestinal obstruction, abdominal exploration. Vital data as temperature, blood pressure, heart rate, oxygen saturation were measured regulary as routine assessment in ICU.

Routine investigations as CBC, eletrolyte, ABG and others were done, assessed in regular way. Also chest X-ray and culture from endotracheal tube were routine investigations in ICU. Clinical suspicion of VAP was based on the classical criteria as: Patient on MV ≥ 48h, two or more of the following criteria: Fever (≥ 38.5ºC) or hypothermia (<36.5ºC), leukocytosis (>11,000/ml) or leukopenia (<4000/ml), purulent tracheal secretions, Pao_2/Fio_2 (<300mmHg) [4].

Exclusion criteria:

- Patients (<18->70) years old.
- Patients who already diagnosed VAP or had any clinical suspicion in <48h of start of MV.

Group classification:

Group A: This group included 50 adult male and female patients at time VAP was suspected, lung ultrasound with direct gram stain examination and culture from endotracheal aspirate were done for each patient when VAP was suspected. Endotracheal aspirate was collected through sterile catheter from endotracheal tube then submitted to direct gram stain examination (EAgram) and culture (EAquant), EAgram was considered positive if any bacteria was visualized after gram stain testing on tracheal secretions, EAquant was positive and confirmed diagnosis of VAP when (≥ 1 microorganism with a concentration ≥ 10^4 CFU/ml) [11]. The ultrasound probe that was used in Lung Ultrasound (LUS) is (3-5MHz) deep convex probe that allowed good visualization of the lung.

Examination was done in supine position in six areas (superior and inferior areas in the anterior, lateral, posterior fields using parasternal, paravertebral, anterior and posterior axillary lines as landmarks, with transverse line between parasternal and paravertebral line through the nipple) Fig. (1). The lateral position was used for posterior lung surface examination and the probe put vertically on the chest tilting it to get good image Fig. (2).

The following ultrasound findings were collected:

1- Small subpleural consolidations (echo-poor regions >0.5cm in diameter).
2- Lobar/hemilobar consolidations defined by a tissue-like pattern.
3- Dynamic linear or arborescent air bronchogram within lobar/hemilobar consolidations (air entrapped within bronchi with simultaneous movement with inspiration) Fig. (4).

Ultrasound findings were collected together in a score called (Ventilator-associated Pneumonia Lung Ultrasound Score) (VPLUS) [12] *that was as followed:*

- ≥ 2 areas with subpleural consolidations, 1 point.
- ≥ 1 area with dynamic linear or arborescent air bronchogram, 2 points.

- Purulent Endotracheal Aspirate (EA), 1 point.

Also ultrasound findings and microbiological findings were collected together in scores called (ventilator-associated pneumonia lung ultrasound direct gram stain examination & culture score) (VPLUS EAgram & VPLUS EAquant) **[12]** *that were as followed:*

- ≥2 areas with subpleural consolidations, 1 point.
- ≥1 area with dynamic linear or arborescent air bronchogram, 2 points.
- Purulent Endotracheal Aspirate (EA), 1 point.

Positive direct gram stain examination or culture (EAgram/EAquant), 2 points.

Sensitivity and specificity of VPLUS, VPLUS EAgram, VPLUS EAquant scores were measured to help in early diagnosis of VAP.

Group B: This group also included 50 adult male and female patients with suspected VAP, chest X-ray was done for every patient in this group with also direct gram stain examination (EAgram) & culture (EAquant) from Endotracheal Aspirate (EA) at time VAP was suspected. New chest X-ray was done to the patients who had chest xray done before clinical suspicion. EA was collected through sterile catheter passed through endotracheal tube, EAgram was considered positive if any bacteria was visualized after gram stain testing on tracheal secretions, EAquant was positive and confirmed diagnosis of VAP when (≥1 microorganism with a concentration ≥104CFU/ml).

The most common findings of chest X-ray in VAP were lung infiltrates or patches that involve one lobe or more or may be scattered all over the lung Fig. (5). Also there were other findings as air bronchograms, para pneumonic effusion, silhouette sign (loss of normal borders between thoracic structures). Culture and gram stain examination results were appeared within 2-4 days, their results were correlated with the findings of lung ultrasound and chest X-ray which were done at time of sucpicion.

Statistical presentation and analysis was conducted by SPSS V.24. Results were expressed as means ± Standard Deviation (SD). Sensitivity and Specificity were calculated for LUS signs (lobar/hemilobar consolidation,dynamic linear/arborescent air bronchograms, and subpleural consolidation), chest X-ray signs, clinical (purulent secretions) and for microbiologic (EA).

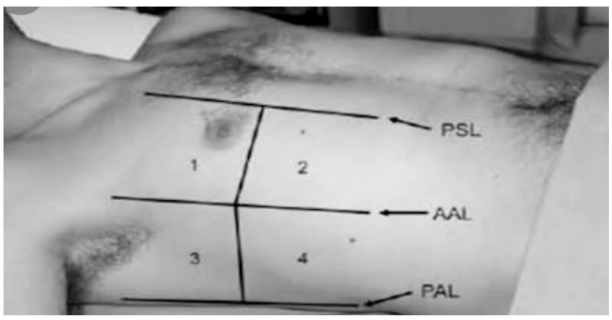

Fig. (1): Anterior zone examination.

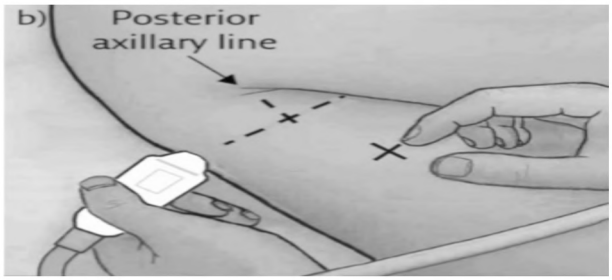

Fig. (2): Posterior zone examination.


Fig. (3): Lung ultrasound examination.

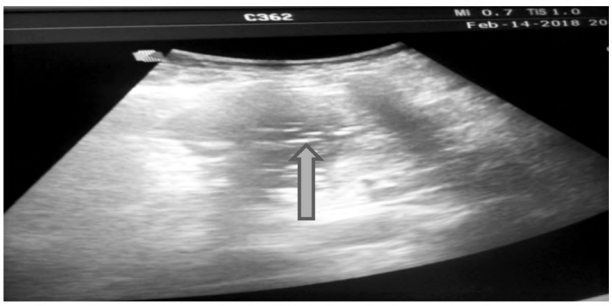

Fig. (4): Air bronchogram inside lobar consolidation.

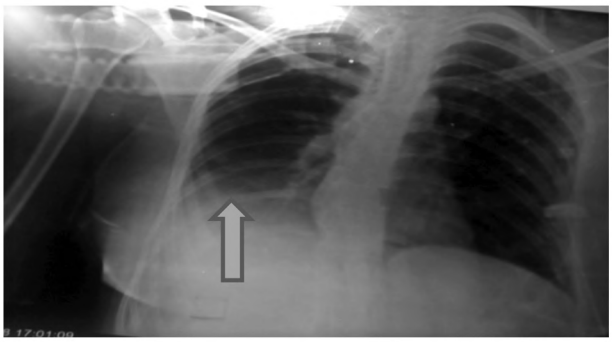
Fig. (5): Chest X-ray infiltrate.

Results

Our results showed that there was no significant difference between both group regarding demographic data (age, BMI & sex), duration of MV at time of suspicion of VAP. Pseudomonas aeruginosa was the most common organism in Group A while Escherichia coli was the most common one in Group B. The first 33 patients were VAP patients in Group A (LUS) while first 30 patients were VAP patients in Group B (CXR).

If we search for the best sensitivity we found it in Group A, presence of ultrasound signs in Group A (LUS) (lobar/hemilobar consolidations, dynamic air bronchogram, subpleural consolidations) separate or combined gave us sensitivity 97%, lobar or hemilobar consolidations had sensitivity 94%, presence of dynamic air bronchogram or subpleural consolidations gave us sensitivity 94%, VPLUS-EAquant ≥3 gave us sensitivity 94%, VPLUS-EAgram ≥3 gave us sensitivity 85%, subpleural consolidation ≥1 had sensitivity 82%.

The best specificity found also in Group A as (air bronchogram + subpleural consolidations + positive culture or positive gram stain examination) gave us the highest specificity 100%, also combination between dynamic air bronchogram ≥1 or 2 and positive culture or gram stain examination had high specificity 94%, combination of (dynamic air bronchogram and subpleural consolidations) gave us high specificity 94%, combination of (lobar/hemilobar consolidations, dynamic air bronchogram and subpleural consolidations) gave us also high specificity 94%, subpleural consolidation ≥2 and positive gram stain examination (EAgram) gave us specificity 94%, (VPLUS-EAquant ≥4, VPLUS-EAgram ≥4 and VPLUS ≥3) had specificity 94%, (VPLUS-EAgram ≥3 and VPLUS ≥2) had specificity 82%, subpleural consolidations ≥1 and positive gram stain examination or culture had specificity 88%, dynamic air bronchogram ≥2 alone had high specificity 88%, dynamic air bronchogram ≥1 also had high specificity 82%.

On the other hand, signs of chest X-ray in Group B had lower sensitivity and specificity compared to lung ultrasound in Group A as chest xray infiltrates gave us sensitivity 53%, specificity 25%, air bronchogram had sensitivity 33%, specificity 40%, presence of (chest xray infiltraes, air bronchogram) separate or combined gave us sensitivity 57%, specificity 25%, also if we compared each sign in both groups with another as lobar consolidations to chest X-ray infiltrates and air bronchogram in both groups we found that lung ultrasound had better results.

According to the above mentioned results, Group A, sensitivity of lung ultrasound reachs 97% and specificity reachs 94%, Group B, sensitivity of chest X-ray reachs 57% while specificity reachs 40%, so lung ultrasound is better than chest X-ray for early diagnosis of VAP.

Area Under the Curve (AUC) was (0.932) for VPLUS, (0.878) for VPLUS-EAquant and (0.948) for VPLUS-EAgram.

Table (1): Demographic data in both groups.

	Group A (LUS)	Group B (CXR)	*p*-value
• Age (year).	37.9±13.7	38.6±10.8	0.801
• BMI (kg/m^2).	25.1 ±5.7	26.6±6.1	0.224
• Sex (M/F).	30/20	28/22	0.839
• Duration of MV at time of suspicion of VAP (days).	4.7± 1.6	5±2.1	0.521

p-value significant if <0.05.

Table (2): Diagnostic value of VPLUS, VPLUS-EAquant, VPLUS-EAgram.

	Sensitivity	Specificity	PPV	NPV	N
VPLUS ≥2	79%	82%	90%	67%	29
VPLUS ≥3	64%	94%	95%	57%	22
VPLUS EAquant ≥3	94%	76%	89%	87%	35
VPLUS EAquant ≥4	73%	94%	96%	64%	25
VPLUS EAgram ≥3	85%	82%	90%	74%	31
VPLUS EAgram ≥4	67%	94%	96%	59%	23

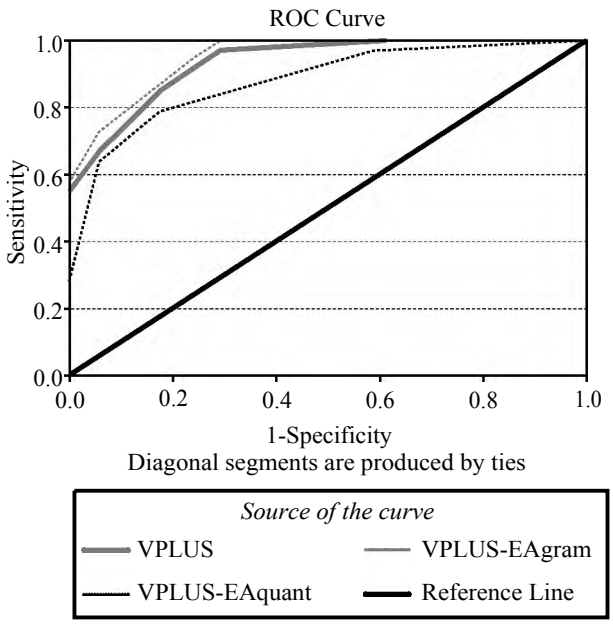

Fig. (6): Receiver Operating Characteristic (ROC) curves for VPLUS, VPLUS-EAquant, VPLUS-EAgram in Group A.

Table (3): Findings of lung ultrasound in Group A.

	Lobar/hemi lobar consolidation	Dynamic air bronchogram ≥1	Dynamic air bronchogram >2	Subpleural consolidation ≥1	Subpleural consolidation >2	Culture (EAquant)	Gram stain (EAgram)	Purulent secretions
1	+	+	+	+	+	+	+	
2	+	+	+	+	+	+	+	+
3	+	+	+	+	–	+	+	+
4	+		–	+	+	–	+	+
5	+	+	+	+	+	+	+	
6	+	–	–	–	–	+	–	+
7	+	+	+	+	–	+	+	–
8	+	+	+	+	+	+	+	+
9	+	+	+	+	+	+	+	+
10	+	+	+	+	+	+	+	–
11	+	–	–	+	+	+	–	+
12	+	+	–	+	–	+	+	+
13	+	+	–	+	+	+	+	+
14	+	–		+	+	+	–	+
15	+	+		+	+	+	+	–
16	+	+	+	+	+	+	+	+
17	+	+	+	–	–	–	+	+
18	+	+	–	+	+	+	–	+
19	+	–	–	+	+	+	+	–
20	+	+	–	+	+	–	+	+
21	+	+	+		–	+	+	+
22	+	–	–	+	–	+	+	+
23		+	–		–	+	+	+
24	+	+	–	+	+	+	–	+
25	–	–	–	–		+	+	+
26	+	+	+	+	+	+	+	+
27	+	–	–	+	–	+	+	+
28	+	+	–	+	+	+		–
29	+	–	–	+	+	+		+
30	+	+	+	–	–	+	+	+
31	+	–	–	+	+	+	+	–
32	+	+	+	+	–	+	+	+
33	+	–	–	+	–	+	+	–
34	+	–	–	–	–	–	–	–
35	–	–	–	–	–	–	–	–
36	+	–	–	–	–	–	–	–
37	–	–	–	–	–	–	–	–
38	+			+	+	+	–	–
39	–			–	–		–	+
40	+	+	+	–	–	–	+	
41	+	+	+	–	–	+	–	–
42	+	–	–			–	–	+
43	–	–	–			–	–	–
44	+	–	–	+	+	–	+	–
45	+	+	–	+	+	–	–	–
46	–	–				–	–	+
47	+			+		–	+	–
48	+			+	+	+		
49	–							+
50	+							
Sensitivity	94%	67%	42%	82%	61%	91%	79%	73%
Specificity	35%	82%	88%	71%	76%	82%	82%	76%
PPV	74%	88%	88%	84%	83%	91%	90%	86%
NPV	75%	56%	44%	67%	50%	82%	67%	59%
N	42	25	16	32	24	33	29	28

Table (4): Combination between findings of lung ultrasound in Group A.

	Sensitivity	Specificity	PPV	NPV	N
Dynamic air bronchogram and subpleural consolidations.	55%	94%	95%	52%	19
Dynamic air bronchogram or subpleural consolidations.	94%	59%	82%	83%	38
Dynamic air bronchogram + subpleural consolidations and lobar/hemilobar consolidations.	55%	94%	95%	52%	19
Dynamic air bronchogram or subpleural consolidations or lobar/hemilobar consolidations.	97%	35%	74%	86%	43
Dynamic air bronchogram >1 and positive culture.	61%	94%	95%	55%	21
Dynamic air bronchogram >1 and positive EAgram.	58%	94%	95%	53%	20
Dynamic air bronchogram >2 and positive culture.	39%	94%	93%	44%	14
Dynamic air bronchogram >2 and positive EAgram.	42%	94%	93%	46%	15
Subpleural consolidations >1 and positive culture.	76%	88%	93%	65%	27
Subpleural consolidations >1 and positive EAgram.	64%	88%	91%	56%	23
Subpleural consolidations >2 and positive culture.	55%	88%	90%	50%	20
Subpleural consolidations >2 and positive EAgram.	42%	94%	93%	46%	15
Dynamic air bronchogram + subpleural consolidations and positive culture.	52%	100%	100%	52%	17
Dynamic air bronchogram + subpleural consolidations and positive EAgram.	45%	100%	100%	49%	15

Table (5): Findings of chest X-ray in Group B.

	Chest X-ray infiltrates	Air bronchogram	Culture (EAquant)	Gram stain examination (EAgram)	Purulent secretions	Chest X-ray infiltrates or air bronchogram	Chest X-ray infiltrates and air bronchogram
1	+	+	+	+	+	+	+
2	+		+	+	–	+	
3	–	–	+	+	+	–	–
4	+	+	+	+	–	+	+
5	+	–	+	–	+	+	–
6	–	–	+	+	+	–	–
7	+	+	–	+	+	+	+
8	+	–	+	–	+	+	–
9	–	–	+	+	+	–	–
10	+	+	+	+	–	+	+
11	–	–	+	+	+	–	–
12	+	+	–	+	+	+	+
13	+	–	+	–	+	+	–
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41	–	–	–	+		–	–
42	+	+	–	–		+	+
43	+	+	–	–	–	+	+
44	–	–	–	+	+	–	–
45	+	+		–	–	+	+
46	+	–		+	+	+	–
47	+	+	–	–	–	+	+
48	–	–	+	–	–	–	–
49	+	+	–	–		+	+
50	+	+			+	+	+
Sensitivity	53%	33%	87%	77%	77%	57%	30%
Specificity	25%	40%	80%	80%	75%	25%	40%
PPV	52%	45%	87%	85%	82%	53%	43%
NPV	26%	29%	80%	70%	68%	28%	28%
N	31	22	30	27	28	32	21

Discussion

VAP is a serious respiratory disease that increases the rate of morbidity and mortality in ICU. VAP was suspected when a new radiographic infiltrate developed in a patient with fever/hypothermia, leukocytosis/leukopenia, purulent tracheal secretions,and impaired oxygenation. Many non infectious processes can cause fever and pulmonary infiltrates so these clinical signs are not specific only to VAP, therefore the need for early detection and early administration of antibiotics.

Lung ultrasound had advantages in diagnosis of VAP as it is a bedside noninvasive technique, easily available, no exposure to radiation, not cost much, safe in pregnant women, highly accurate, but it had some limitations as LUS is operator dependent and requires a trained physician, some patients may be difficult to examine by using LUS (eg, obese individuals, patients with subcutaneous emphysema or large thoracic dressings). Sonographic signs of VAP were lobar/hemilobar consolidations, subpleural consolidations, dynamic air bronchogram or fluid bronchogram.

Chest X-ray used as a routine tool for diagnosis of VAP by finding new lung infiltrates which may bilateral scattered, lobar or hemilobar but it had disadvantages as radiation, difficult in transporting device and critically ill patients, cost, not easily available, not highly accurate and not safe in pregnant women, sometimes bad quality of films. Culture from endotracheal tube is the gold standard for diagnosis of VAP which is positive when (≥ 1 microorganism with a concentration $\geq 10^4$ CFU/ml) but it needed 2 to 4 days to appear. Mechanism of VAP came from migration of microorganisms through endotracheal tube by positive-pressure MV.

The sensitivity and specificity of LUS signs were high especially when combined with microbiological findings as (air bronchogram + subpleural consolidations + positive culture or positive gram stain examination) gave us the highest specificity 100% and PPV 100%, presence of ultrasound signs (lobar/hemilobar consolidations, dynamic air bronchogram, subpleural consolidations) separate or combined gave us sensitivity 97%, lobar or hemilobar consolidations had sensitivity 94% found in most patients, presence of dynamic air bronchogram or subpleural consolidations gave us sensitivity 94%, combination of (dynamic air bronchogram and subpleural consolidations) gave us high specificity 94%, combination between dynamic air bronchogram ≥ 1 or 2 and positive culture or gram stain examination had high specificity 94%, subpleural consolidation ≥ 2 and positive gram stain examination (EAgram) gave us specificity 94%, subpleural consolidations ≥ 1 and positive gram stain examination or culture had specificity 88%, also VPLUS-EAquant ≥ 3 gave us sensitivity 94% and (VPLUS-EAquant ≥ 4, VPLUS-EAgram ≥ 4 and VPLUS ≥ 3) had high specificity 94% while chest xray in Group B (CXR) had lower sensitivity and specificity compared to lung ultrasound in Group A.

In agreement with our results, Mongodi et al., [12],assessed the accuracy of lung ultrasound in 99 patients with suspected VAP, lobar/hemi lobar consolidation occurred universally in patients without VAP, with sensitivity 93% and specificity was 0. One or more areas with a small subpleural-consolidation had a sensitivity of 81% and a specificity of 41%, whereas one or more areas with a consolidation and dynamic air bronchograms had a sensitivity of 44% and a specificity of 81%. The specificity of these signs increased when they were present in a greater number of areas, VPLUS-EAgram ≥ 4 had a sensitivity of 48% and a specificity of 97%, VPLUS-EAgram ≥ 3 had a sensitivity of 78 up to 88% and a specificity of 77 up to 90%, VPLUS-EAquant ≥ 4 had a sensitivity of 57% and a specificity of 96%, VPLUS-EAquant ≥ 3 had a sensitivity of 83 up to 92% and a specificity of 79 up to 92%.

In agreement with our results, Cortellaro et al., [13],prospective study was done on 120 patients, pneumonia suspected by clinical criteria as leukocytosis, leucopenia, fever hypoxia, new infiltrate in chest xray, diagnosis by ultrasound by detection of consolidations and dynamic air bronchogram. This gave us sensitivity of 99% and specificity of 95%, makes ultrasound better than X-ray for diagnosis of pneumonia.

Similarly, Lichtenstein et al., **[14]**, prospective study that was done on 260 patients, suspicion based on clinical picture and new CXR infiltrates, using lung ultrasound for detection of dynamic air bronchogram in mechanically ventilated patients with pneumonia. The sensitivity reported in this study was 89% and the specificity was 94% in diagnosing VAP. Also in agreement with our results, Berlet et al., **[15]**, performed daily LUS for at least 5 days in 57 patients and assessed consolidations, dynamic air bronchogram, fluid bronchogram. Lung ultrasound had a sensitivity of 92% and a specificity of 65% (40-80%).

In disagreement with our results, Corradi et al., **[16]**, prospective study was done on 35 patients in

ED, pneumonia suspected clinically and chest X-ray infiltrates, ultrasound diagnosis of pneumonia done by finding consolidations and air bronchograms. The sensitivity of lung ultrasound was 57% that is much lower than ours, specificity up to 86%. This disagreement may be due to number of patients in this study was lower than our study, may be also because inclusion involved community acquired not only ventilator associated pneumonia.

In disagreement with our results, Gatt et al., **[17]**, this study was done on large number of patients 507 in ED, chest radiology was done for detection of any abnormalities such as consolidations, pleural effusion, congestion or any abnormalities, the sensitivity of consolidations by chest X-ray was 65% and specificity was 95%, this comes with disagreement with our results which chest X-ray has lower results in sensitivity and specificity, this may be due to large number of patients in this study, also not specific for studying consolidations only but any other abnormalities as well.

Also in disagreement with our results, Zagli et al., **[18]**, retrospectively investigated the accuracy of alveolar consolidation in a comprehensive LUS examination. Sonographic consolidation had a sensitivity of 59% and a specificity of 84%, our results consolidations have higher sensitivity reached to 94%. It may be due to Zagli worked on more patients 221. Also this study assessed the accuracy of LUS, when used in conjunction with Clinical Pulmonary Infection Score (CPIS) and Procalcitonin.

Xirouchaki et al., **[19]** prospective study was done on 42 mechanically ventilated patients in ICU. Chest X-ray, lung ultrasound, CT scan were done for diagnosis of consolidation, interstitial syndrome, pneumothorax and pleural effusion. According to consolidations by lung ultrasound, sensitivity was 100%, specificity was 78% while by chest X-ray, sensitivity was 38%, specificity was 89%, this study comes with agreement with our study in high sensitivity of lung ultrasound, lower sensitivity of chest X-ray but it comes with disagreement with our study in high specificity of chest X-ray and became higher than lung ultrasound.

Conclusion:

Lung ultrasound has several advantages over chest X-ray. It has high diagnostic accuracy in diagnosis of VAP. Its sensitivity and specificity higher than chest X-ray, so lung ultrasound is better than chest X-ray for early diagnosis of VAP.

Conflicts of interest:

No conflicts of interest declared.

Authors' contributions:

All authors had equal role in design, work, statistical analysis and manuscript writing.

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الموجات فوق الصوتية على الرئة فى التشخيص المبكر للإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى

يعتبر الإلتهاب الرئوى أحد عدوى الجهاز التنفسى ويعد الإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى أحد أشهر أنواع العدوى بالعناية المركزة ومن الحالات الحرجه بها والمرتبط بإرتفاع معدلات الوفاة بالمستشفى. يتم التكهن بالإصابة بمرض الإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى بعد مرور يومين أو أكثر على الإتصال بجهاز التنفس الصناعى مع وجود بعض الأعراض مثل إرتفاع درجة حرارة الجسم فوق ٣٨.٥ درجة أو إنخفاضها تحت ٣٦.٥ درجة، إرتفاع عدد كرات الدم البيضاء فوق معدلها الطبيعى (١١.٠٠٠) إنخفاضها تحت (٤.٠٠٠)، وجود إفرازات صديدية من الأنبوبة الحنجرية، إنخفاض نسبة الأوكسجين بالدم، ظهور تصلبات جديدة بالأشعة العادية على الصدر. تشخيص الإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى يتم بواسطة الأشعة العادية على الصدر، الموجات فوق الصوتية على الرئة، سحب مزرعة بكتيرية من الأنبوبة الحنجرية لفحصها وأيضا يتم فحصها بالصبغة.

الهدف من الدراسة: دراسة دور الموجات فوق الصوتية على الرئة فى التشخيص المبكر للإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى مقارنة بالأشعة العادية على الصدر.

المرضى وطرق البحث: قد أجريت هذه الدراسة من يونيه ٢٠١٧ إلى مايو ٢٠١٨ بالعناية المركزة الجراحية فى مستشفيات جامعة طنطا على مائة مريض من ١٨ إلى ٧٠ سنة.

معايير الإشتمال: مائة مريض مشتبه إصابتهم بالإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى مقسمة على مجموعتين، كل مجموعة ٥٠ مريض ما بين ١٨ إلى ٧٠ سنة متصلين بجهاز التنفس الصناعى ليومين أو أكثر مع وجود بعض الأعراض.

المجموعة الأولى: تشمل ٥٠ مريض مشتبه إصابتهم بالإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى. يتم عمل الموجات فوق الصوتية على الرئة للمرضى مع سحب مزرعة بكتيرية من الأنبوبة الحنجرية وفحصها بالصبغة لمعرفة ما إذا كانت سلبية أم إيجابية عند الإشتباه بالمرض، ومن العلامات التى تدل على الإصابة بالمرض فى الرئة.

- تصلبات صغيرة تحت الغشاء البلورى.
- تصلبات منتشرة بالرئة تشبه الأنسجة مثل الكبد.
- تجمعات هوائية خطية أو متشبعة بداخل الشعب الهوائية تتحرك مع التنفس.

تعد نتيجة المزرعة إيجابية عند وجود ميكروب واحد أو أكثر أما الصبغة فتعد إيجابية عند رؤية أى ميكروب فى العينة، ويتم عمل مقياس للموجات فوق الصوتية على الرئة فى الإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى للمساعدة فى التشخيص المبكر للمريض ويحسب كالآتى:

- منطقتين أو أكثر من تصلبات صغيرة تحت الغشاء البلورى تأخذ نقطة واحدة.
- منطقة أو أكثر من تجمعات الهوائية بالشعب الهوائية تأخذ نقطتين.
- إفرازات صديدية من الأنبوبة الحنجريبة تأخذ نقطة واحدة.

يتم إدراج نتيجة المزرعة البكتيرية والفحص المباشر بالصبغة مع هذا المقياس وإذا كانت نتيجة الفحص المباشر بالصبغة أو المزرعة البكتيرية إيجابية تأخذ نقطتين.

\المجموعة الثانية: تشمل ٥٠ مريض، يتم عمل أشعة عادية على الصدر لهم مع سحب مزرعة بكتيرية من الأنبوبة الحنجرية وفحصها بالصبغة لمعرفة ما إذا كانت سلبية أم إيجابية عند الإشتباه بالمرض، ومن العلامات التى تظهر بالأشعة وتدل على المرض ظهور عتامة متفرقة بالرئة أو وجود تجمعات هوائية بداخل الشعب الهوائية.

\النتائج: تمت جدولة النتائج وتحليلها إحصائيا وقد وجد أنه:

- لا يوجد فرق ذو دلالة إحصائية فيما يتعلق بالبيانات الديموغرافية بالمجموعتين مثل العمر، النوع والوزن.
- نتائج المجموعتين أظهرت أعلى الأرقام فى المجموعة الأولى حيث أن درجة حساسية الموجات فوق الصوتية على الرئة فى تشخيص الإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى وصلت ٩٧٪ ودرجة النوعية أو خصوصيتها وصلت ٩٤٪. مقياس الموجات فوق الصوتية على الرئة فى الإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى مع المزرعة البكتيرية أو الفحص المباشر الصبغة أظهرت نتائجة أنه إذا كان ٣ أو أكثر فإن درجة حساسيته تصل ل٩٤٪ وإذا كان ٤ أو أكثر فإن درجته النوعية تصل ل ٩٤٪ أيضا.
- أما عن المجموعة الثانية فأظهرت معدل منخفض من النتائج حيث وصلت درجة حساسيته الأشعة العادية على الصدر فى تشخيص الإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى ل ٥٧٪ ودرجة النوعية أو التخصصية ل ٤٠٪، وبناءا عليه فإن نتائج المجموعة الأولى التى تشمل الموجات فوق الصوتية على الرئة أعلى وأفضل من نتائج المجموعة الثانية التى تشمل الأشعة العادية على الصدر ف التشخيص المبكر للإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى.

\الإستنتاج من هذا \البحث: من دراسة النتائج نستنتج أن الدرجة التشخيصية للموجات فوق الصوتية على الرئة أعلى وأفضل من درجة الدرجة التشخيصية للأشعة العادية على الصدر فى التشخيص اللمبكر للإلتهاب الرئوى المصاحب لجهاز التنفس الصناعى.