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Original Article

Anaesthesia Section

Diagnostic Accuracy of Lung Ultrasound versus Chest Radiograph for Early Diagnosis of Ventilator-associated Pneumonia: An Observational Study

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ABSTRACT

Introduction: Ventilator-associated Pneumonia (VAP) is one of the leading causes of morbidity and mortality in Intensive Care Unit (ICU) and is diagnosed by clinical symptoms, Chest X-ray (CXR), Computerised Tomography (CT) and microbiology test in routine practice.

Aim: To compare the diagnostic accuracy of Lung Ultrasound (LUS) with gold standard CXR, with or without modified Clinical Pulmonary Infection Score (CPIS) score, for the diagnosis of VAP in ICU.

Materials and Methods: This prospective observational study was carried out on 40 mechanically ventilated patients in Indira Gandhi Medical College and Hospital, Shimla, Himachal Pradesh, India over the duration of one year from November 2018-October 2019. The study was continued till VAP was diagnosed by all three modalities (CXR, LUS and microbiology) or to the maximum of 10 days postintubation whichever was less. Data was analysed with appropriate statistical tools "MedCalc".

Results: The mean age of patients was 45.78±15.99 years and there were 28 male and 12 females. The diagnosis of VAP was earliest with LUS (3.1±0.81 days) and (4.22±1.23 days) with CXR when studied alone ($p<0.0001$). However, when LUS was incorporated in CPIS score instead of CXR the diagnostic accuracy were statistically similar ($p>0.05$). During the early days (3 and 4 day) the diagnostic accuracy (AUC), sensitivity and specificity of LUS was better and was (0.70-0.74, 57-90%) than (0.5; 16.7-83%) with CXR. Fifth day onwards AUC was better with CXR (0.79-0.81) as compared to (0.54-0.70) with LUS. Total leucocyte count (TLC), fever, P/F ratio and sputum quantity were observed individually between the VAP and non VAP group patients and were found to be similar ($p>0.05$).

Conclusion: According to the present observational study, LUS can accurately diagnose VAP when other objective tools like CPIS, CXR and microbiology are inconclusive.

Keywords: Area under curve, Artificial, Fever, Respiration, Sensitivity and specificity, Sputum

INTRODUCTION

Early diagnosis of ventilator-associated pneumonia is of paramount importance for reducing the morbidity and mortality of ICU patients, but there is no universally accepted gold standard diagnostic criterion for diagnosing VAP till date. The risk of VAP is greatest (3%) during the first 5 days of mechanical ventilation with mean appearance on 3.3 days, thereafter it declines to 2%/day till 10 day postintubation [1].

Centres for Disease Control and prevention (CDC) manual in January 2020 recommends CXR, clinical parameters with P/F ratio and microbiology for Ventilator Associated Events (VAE) surveillance, whereas, european council in their Multiple Criteria Decision Analysis (MCDA) recommend use of above parameters with biomarkers C-reactive Protein (CRP) or Procalcitonin (PCT) [2,3]. Inspite of the fact that LUS is routinely being used world over, these recent guidelines are silent on the diagnostic accuracy of LUS for this purpose [4-6]. Ever since the Point Of Care Ultrasound (POCUS) has entered into anaesthetist domain it is being used worldwide by intensivists for diagnosis of various diseases by its use. Examination of lung by LUS is one such modality which is now mastered by anaesthetists. Although, its use looks promising but, also it has its own limitations as 20% of the lung surface is not visualised owing to the shielding by bony structures like clavicle and scapula [7,8]. Moreover, its use is difficult in obese patients and in those with chest dressings. Inspite of the short comings various researchers have given sensitivity ranging from 78%-96.7% when LUS is included in CPIS score for diagnosis of the VAP [8,9]. Researchers have highlighted the benefits of replacing CXR with LUS in ICU but as there is paucity of studies on this topic in literature hence the guidelines for VAP diagnosis have still not included LUS as a tool for diagnosing VAP [10,11].

Thus, the study aimed to see the diagnostic accuracy of LUS over CXR in CPIS score for diagnosis of VAP in ICU.

MATERIALS AND METHODS

The present prospective observational study was done from November 2018 to October 2019 on patients admitted in 6 bedded ICU of Indira Gandhi Medical College and Hospital, Shimla, Himachal Pradesh, India. Institutional review committee had approved the study vide letter no. HFW (MC)SURG/477 dated 30.10.2018.

Inclusion criteria: Patients with expected mechanical ventilation of atleast a week, even those intubated in the ward <48 hours back were included in this study.

Exclusion criteria: Patients on mechanical ventilation for less than 48 hours, with prior lung consolidation, postcardiopulmonary resuscitation, thoracic dressings and drapings, obese patients will thick chest wall, prior hospitalisation within past 90 days, patient on immunosuppressive therapy, witnessed aspiration and patients already intubated inward >48 hours back were excluded.

Study Procedure

The patients were studied till the VAP was diagnosed with all three modalities i.e., LUS/CXR, and microbiology (individual score=2) or for a maximum of 10 days in ICU. The validated score for VAP diagnosis is CPIS score >6 (it has TLC, sputum, CXR, P/F ratio and

microbiology as its components). Each sign is given maximum of two points. So, even one parameter is not present other can add up to a score to diagnose VAP of >6 points.

Microbiology reporting takes minimum of five days to come, hence, by that time the patient has inconclusive diagnosis or if the clinical other parameters are positive then they add up to the score value. Each parameter (LUS/CXR and microbiology) has maximum of two points allotted to them individually. So, if any one of the parameters had a maximum score value of two, it was presumed that VAP is present. The patients were excluded once they were positive by all three methods and they were excluded to see the diagnostic accuracy of these individual's investigations. Modified CPIS score with LUS/X-ray was used and highest temperature recorded during the day was considered for the score [12,13]. Nature of sputum, if any, was noted. TLC, Arterial Blood Gas (ABG), CXR and LUS were done daily. Sputum qualitative microbiology was done on 3rd, 5th, 7th postintubation day. Microbiology reporting till sensitivity testing takes minimum of three days and the first report was sent on third day (48 hours after intubation), thus during this period till 5th day when the first report was available score of zero was used for calculating the modified CPIS score. The available latest microbiology reports score was used after 5th day till fresh new report came [Table/Fig-1].

Investigation	CPIS (with Chest X-Ray)	CPIS (with LUS)
Inflammatory markers	Temp (°c) ≥38.5 and ≤38.4=1 point ≥39 or 36=2 point WBC (cells/µL) <4000 OR >11000=1 Point <4000 or >11000+band forms ≥50%	Temp (°c) ≥38.5 and ≤38.4=1 point ≥39 or 36=2 point WBC (cells/µL) <4000 or >11000=1 point <4000 or >11000+band forms ≥50%
Sputum	Non purulent, abundant=1 point Purulent, abundant=2 point	Non purulent, abundant=1 point Purulent, abundant=2 point
Chest radiography/ LUS	Diffuse Infiltrate=1 point Localised infilterate=2 points Progressive infilterate=2 points	Multiple B lines: 1 point Air bronchograms/consolidation: 2 points Shred sign: 2 points
Microbiology	Heavy microbiologic quantitative +ve=1 point Microbiologic quantitative +ve and same pathogenic bacteria seen on gram stain=2 points	Heavy microbiologic quantitative +ve=1 point Microbiologic quantitative +ve and same pathogenic bacteria seen on gram stain=2 points
P/F Ratio	≤240 Without ARDS=2 points	≤240 Without ARDS=2 points

[Table/Fig-1]: Clinical Pulmonary Infection Score (CPIS with LUS and CXR). A score of 6 was suggestive of VAP

Initially, LUS was performed with the help of the radiologist who had expertise over LUS and thereafter, the LUS examination was done independently by the anaesthesiologist. LUS was done with the ultrasound machine, with the convex probe using bandwidth 3-5 MHz. The probe was placed vertically along each space in midclavicular line, anterior axillary line and posterior axillary line on both sides. Antero-posterior CXR was taken in the supine or semi sitting position using portable X-ray equipment. CPIS score with CXR was considered to be the gold standard for diagnosing VAP.

STATISTICAL ANALYSIS

All the data was collected, tabulated and then analysed with appropriate statistical tools "MedCalc". Chi-square test, Student's unpaired and paired t-test, Karl Pearson's Correlation Coefficient was used to correlate different parametric data at a time. The p-value of ≤0.05 was considered as significant.

RESULTS

Sixty patients admitted in the six bedded ICU were assessed for eligibility but 20 were excluded because of prior consolidation (n=3) witnessed aspiration (n=4) ventilation <48 hours (n=2) prior hospitalisation (n=4) already intubated in ward >48 hours back (n=3) post CPR (n=4) and ultimately 40 patients were enrolled.

Out of these 40 patients enrolled, nine each were of organophosphorus poisoning and head injury, eight had sepsis (multiorgan dysfunction syndrome), six were of poly trauma, five were with hemiparesis or quadriparesis and one each were of hypertensive emergency, Moya Moya disease and snake bite.

There were 28 males and 12 females in the study group of mean age 45.78±15.99 years. The mean age in years of males in the study group was 44.04±16.75 and was 48.78±15.79 for the females (p=0.9567). CPIS score and LUS, CXR scores were combined and individually studied and recorded on various ICU days [Table/Fig-2,3].

CPIS		LUS n (%)	CXR n (%)	p-value
Baseline	0	3 (7.5%)	3 (7.5%)	0.9959
	1	11 (27.5%)	13 (32.5%)	
	2	10 (25%)	9 (22.5%)	
	3	6 (15%)	7 (17.5%)	
	4	7 (17.5%)	5 (12.5%)	
	5	2 (5%)	2 (5%)	
	6	1 (2.5%)	1 (2.5%)	
Day-3 (N=40)	1	3 (7.5%)	6 (15%)	0.2322
	2	9 (22.5%)	10 (25%)	
	3	12 (30%)	9 (22.5%)	
	4	6 (15%)	10 (25%)	
	5	8 (20%)	2 (5%)	
	6	1 (2.5%)	3 (7.5%)	
	7	1 (2.5%)	0 (0%)	
Day-4 (N=40)	1	0 (0%)	1 (2.5%)	0.163
	2	1 (2.5%)	5 (12.5%)	
	3	12 (30%)	10 (25%)	
	4	5 (12.5%)	10 (25%)	
	5	13 (32.5%)	7 (17.5%)	
	6	5 (12.5%)	6 (15%)	
	7	4 (10%)	1 (2.5%)	
Day-5 (N=40)	2	1 (2.5%)	4 (10%)	0.552
	3	9 (22.5%)	11 (27.5%)	
	4	1 (25%)	7 (17.5%)	
	5	7 (17.5%)	10 (25%)	
	6	7 (17.5%)	4 (10%)	
	7	4 (10%)	2 (5%)	
	8	1 (2.5%)	2 (5%)	
	9	1 (2.5%)	0 (0%)	
Day-6 (N=40)	2	0 (0%)	5 (12.5%)	0.3368
	3	11 (27.5%)	8 (20%)	
	4	6 (15%)	5 (12.5%)	
	5	3 (7.5%)	7 (17.5%)	
	6	8 (20%)	4 (10%)	
	7	6 (15%)	5 (12.5%)	
	8	3 (7.5%)	4 (10%)	
	9	2 (5%)	1 (2.5%)	
	10	1 (2.5%)	1 (2.5%)	
Day-7 (n=31)	2	0 (0)%	0 (0%)	0.3467
	3	0 (0%)	1 (3.23%)	
	4	1 (3.23%)	5 (16.13%)	
	5	7 (22.58%)	3 (9.68%)	
	6	5 (16.13%)	6 (19.35%)	
	7	4 (12.90%)	7 (22.58%)	
	8	10 (32.26%)	5 (16.13%)	
	9	2 (6.45%)	2 (6.45%)	
	10	2 (6.45%)	2 (6.45%)	

Day-8 (n=17)	4	0 (0%)	2 (11.76%)	0.5256
	5	2 (11.76%)	3 (17.65%)	
	6	4 (23.53%)	1 (5.88%)	
	7	3 (17.65%)	4 (23.53%)	
	8	5 (29.41%)	5 (29.41%)	
	9	2 (11.76%)	2 (11.76%)	
	10	1 (5.88%)	0 (0%)	
Day-9 (n=8)	6	2 (25%)	2 (25%)	1.000
	7	0 (0%)	0 (0%)	
	8	3 (37.5%)	3 (37.5%)	
	9	1 (12.5%)	1 (12.5%)	
	10	1 (12.5%)	1 (12.5%)	
	11	1 (12.5%)	1 (12.5%)	

[Table/Fig-2]: Scores of CPIS with LUS and CXR over the days.

Baseline investigation N=40		LUS No. of patients (%)	CXR No. of patients (%)	p-value (Chi-square test)
Baseline				
Scoring	0	21 (52.5%)	28 (70%)	0.2019
	1	18 (45%)	12 (30%)	
	2	1 (2.5%)	0 (0%)	
Day-3 n=40				
Scoring	0	4 (10%)	11 (27.5%)	0.2446
	1	29 (72.5%)	28 (70%)	
	2	7 (17.5%)	1 (2.5%)	
Day-4 n=40				
Scoring	0	0 (0%)	6 (15%)	<0.0001
	1	20 (50%)	30 (75%)	
	2	20 (50%)	4 (10%)	
Day-5 N=40				
Scoring	0	0 (0%)	2 (5%)	0.0004
	1	19 (47.5%)	33 (82.5%)	
	2	21 (52.5%)	5 (12.5%)	
Day-6 n=40				
Scoring	0	0 (0%)	2 (5%)	0.0089
	1	14 (35%)	25 (62.5%)	
	2	26 (65%)	13 (32.5%)	
Day-7 n=31				
Scoring	0	0 (0%)	0 (0%)	0.0001
	1	2 (6.45%)	17 (54.84%)	
	2	29 (93.55%)	14 (45.16%)	
Day-8 n=17				
Scoring	0	0 (0%)	0 (0%)	0.0047
	1	0 (0%)	8 (47.06%)	
	2	17 (100%)	9 (52.94%)	
Day-9 n=8				
Scoring	0	0 (0%)	0 (0%)	0.7799
	1	0 (0%)	0 (0%)	
	2	8 (100%)	8 (100%)	

[Table/Fig-3]: Individual scoring of LUS and CXR examination at various time interval.

The mean baseline value of the modified CPIS was 2.4 in LUS and 2.2 in CXR group. Although, it increased over the days but it became ≥6 in both the groups. On 7th day when it was 6.8 in LUS and 6.48 in CXR group (p>0.05) [Table/Fig-2].

The baseline findings were recorded on the day of ICU admission and it was observed that one patient (2.5%) had CPIS ≥6 but in this patient LUS score and CXR score were one only, another patient in LUS group had score of two but his cumulative CPIS score was <6, 18 (45%) patients in LUS and 12 (30%) patients in CXR had a score 1 and rest of patients on baseline had a score 0 in these two modalities. Thereafter, daily recordings were done (48 hours postintubation) and it was labelled as day 3.

On day 3, out of 40 patients two patients in these modalities individually 7 (17.5%) patients in LUS and only 1 (2.5%) patient in CXR had a score=2. On day 4, 20 (50%) patients in LUS and 4 (10%) patients in CXR had a score=2 whereas, nine patients with LUS and seven patients with CXR had a CPIS ≥6. On day 5, 13 patients with LUS and 8 patients with CXR had CPIS ≥6. LUS (score=2) was seen in 21 (52.5%) patients and in 5 (12.5%) patients of CXR group (p=0.0004). First available microbiology report was positive in 13 patients (p<0.0064). There was no overlap of these positive reports amongst patients thus none was excluded on day 5.

On day 6, 26 (65%) patients in LUS and 13 (32.5%) patients in CXR had individual score=2, out of these patients 20 with LUS and 15 patients with CXR had a CPIS score ≥6. Out of 13 patients who were positive on culture 9 had CPIS score >6 and LUS/CXR score=2 hence these were excluded. On day 7, in remaining 31 patients, 29 (93.5%) patients in LUS and 14 (45%) in CXR had a score=2 whereas, 23 patients with LUS and 22 patients with CXR had a CPIS score ≥6. Positive microbiology report was seen in 26 patients (p<0.0013) but only 14 were positive by all modalities thus were excluded. On day 8, all 17 remaining patients in LUS and 9 (52.9%) patients in CXR group had evidence of VAP (p=0.0047). Fifteen patients with LUS and 12 patients with CXR had a CPIS score ≥6. Twelve patients (p=0.3138) had a positive microbiology report. Thus, nine patients were excluded. On day 9, all remaining patients were positive by all three modalities.

When LUS and CXR scores were studied independently then from day 4 onwards till day 8 more patients in LUS group had a score=2 than CXR group. Thus, on all these days the percentage of patients found positive by LUS method was higher and was 50% on day 4 and increased to 100% till day 8. On the contrary, even on day 8 only 9 patients had a score of 2 and still 50% had a score 1 on CXR examination (p≤0.0047). On day 9, all the eight remaining patients were diagnosed with VAP by LUS, CXR, CPIS score and microbiology [Table/Fig-3].

Comparison of the timing of appearance and diagnostic accuracy of VAP in CXR and LUS [Table/Fig-4,5]: The timing of appearance of VAP was earliest with LUS (3.1±0.81 days) followed by CXR which was 4.22±1.23 days (p<0.0001) [Table/Fig-4].

Time of appearance	DX-LUS (n=40)	DX-CXR
Mean	3.1	4.225
Standard deviation	0.81	1.23
p-value (paired t-test)	<0.0001	

[Table/Fig-4]: Time of appearance of VAP (DX=Diagnostic accuracy).

The sensitivity and specificity of LUS was high than that of CXR on 3rd and 4th day but, later on the specificity of LUS showed a downward trend (90.91-12.50) whereas, specificity increased over the days with CXR (82.3-100). The diagnostic accuracy (AUC) during this period was acceptable i.e., 0.74 and was low 0.54 with CXR. The diagnostic accuracy over the days decreased with LUS (0.74-0.54) whereas, it increased for CXR (0.5-0.8). It became better for CXR over LUS after 4 day and was excellent on 7 day (0.82) onwards [Table/Fig-5].

Investigation	Timeline (Day)	Sensitivity	Specificity	PPV	NPV	DP	AUC	Odds ratio	p-value
Lung ultrasound	3	57.14%	90.91%	57.14%	90.91%	17.50%	0.74	13.33	0.0079
	4	80%	58%	60%	79%	50%	0.70	6.93	0.0021
	5	78%	65%	75.30%	58.57%	50%	0.71	6.94	0.0101
	6	85%	55%	65.38%	78.57%	50%	0.70	6.93	0.0121
	7	95.65%	12.50%	75.86%	50%	74.19%	0.54	3.14	0.774
Chest X-Ray	3	16.67%	82.35%	14.29%	84.85%	15%	0.50	0.93	0.9535
	4	27%	83%	14%	85%	15%	0.50	0.90	0.9230
	5	67%	86%	79%	82%	38%	0.79	14.27	0.0001
	6	66.67%	88%	76.92%	81.48%	37.50%	0.77	14.67	0.0011
	7	63.64%	100%	100%	52.94%	70.97%	0.82	32.41	0.0216
	8	90%	71.43%	81.82%	83.33%	58.82%	0.81	22.50	0.0207

[Table/Fig-5]: Diagnostic accuracy of Lung Ultrasounds (LUS) and chest X-Ray (CXR).
PPV: Positive predictive value; NPV: Negative predictive value; AUC: Area under curve; DP: Disease prevalence; OR: Odds ratio

Clinical parameters of CPIS score studied individually: There was no correlation between the temperature recording, TLC count, nature of the sputum and Pao2/fio2 ratio when studied individually (p>0.05) [Table/Fig-6]. Pleural effusion was detected in six patients by LUS method over the study days (p≥0.1135).

P/F ratio		No. of patients	Percentage	p-value (Chi-square test)
Baseline (N=40)	≤240	18	45%	0.5023
	>240	22	55%	
Day 3 (N=40)	≤240	14	35%	0.0139
	>240	26	65%	
Day-4 (N=40)	≤240	18	45%	0.5023
	>240	22	55%	
Day-5 (N=40)	≤240	18	45%	0.5023
	>240	22	55%	
Day-6 (N=40)	≤240	20	50%	0.8231
	>240	20	50%	
Day-7 (n=31)	≤240	16	40%	0.1175
	>240	15	60%	
Day-8 (n=17)	≤240	13	76.47%	<0.0001
	>240	4	23.53%	
Day-9 (n=8)	≤240	4	50%	0.7237
	>240	4	50%	

[Table/Fig-6]: Comparisons of P/F Ratio observed on various ICU days.

DISCUSSION

Centres for Disease Control and prevention uses term Ventilator-associated Event (VAE) surveillance instead of VAP/VAT (Ventricular Associated Tracheobronchitis) to include all events related to mechanical ventilation [2]. Yunzhou F et al., concluded that this definition misses out few cases of VAP and many believe that VAP and VAT are similar and VAT is colonisation of proximal trachea but it's unlikely that the infection will remain confined to that area only and it will eventually progress to full blown VAP [14].

Adamantia L et al., inferred that VAP is diagnosed by clinical suspicion and confirmed by microbiology and imaging techniques [15], but CDC is lenient as they have included semi-qualitative scores also in VAE surveillance, thus, in the present study semi-quantitative scores of microbiology were used [2]. Microbiology results are essential not only to confirm the diagnosis but also to target antibiotic therapy but they required minimum of 48 hours in the present study institution. Therefore, this could not guide the early clinical management of the suspected VAP patient.

Modified CPIS is still considered a semi objective tool with low to moderate accuracy with reported sensitivity of 72%, specificity of 85% and overall accuracy of 79% because of its high inter observational variability [12]. As it involves simple parameters which are routinely recorded in ICU, it still finds place in most of the diagnostic studies the world over [12,13]. To increase its accuracy, researchers have used various biomarkers as rapid POCT like CRP, Procalcitonin (PCT), automated microscopy, multiplex Polymerase Chain Reaction (PCR), and LUS with varying sensitivities [16-19]. There are weak recommendations for the use of these biomarkers for diagnosing VAP. Guidelines still advocate clinical parameters, microbiology, radiological techniques like CXR and CT scan for the diagnosis [2,3]. Although Peris A et al., addressed the effectiveness of bedside LUS in the ICU as early as in 2010, and found a significant decrease in in number of CXR (26%) and CT scans (47%) with no significant adverse changes to patient mortality [20].

The LUS has still not found its place in recent guidelines although, it is readily available in ICU, is free of radiation, interpretations are immediately available, it can be used in pregnant females and can assist not only for diagnosis but also for monitoring the treatment of VAP [8,21]. Guyi W et al., reported that physician who are not ultrasound experts could diagnose pneumonia in 84% non ventilated patients with 88-90% sensitivity [7]. Thus, they also proved that it had a short learning curve. Researchers have reported increased sensitivity and specificity when CPIS was used with LUS. Staub LJ et al., reported CPIS with LUS to be 78% sensitive and 77% specific over 48% sensitive and 97% specific when used alone. El-Helbawy RH et al., reported CPIS with LUS having 96.7% sensitivity and 97.5% accuracy over sensitivity of 93.3% for pneumonia when LUS was used alone [9,21]. Abdo-Cuza A et al., Mongodi S et al., and Xie C et al., reported better sensitivity of 60-100% and specificity of 83-90% with LUS to that of CXR (23-72% and 27-83%), Mongodi S et al., reported 86% PPV for air bronchogram with AUC of 0.832-0.743 while Xie C et al., could diagnose 98% sensitive and 95% specific lung pathologies in postoperative period with LUS [8,22,23]. Some researchers used CT Thorax to confirm the accuracy of LUS over CXR. Out of 21 cases diagnosed with VAP by CT scan by Mohsen A et al., LUS was able to detect all 21 cases of pulmonary consolidation with sensitivity and specificity of 100% and 81.4% whereas, CXR could detect only 12 cases with sensitivity and specificity of 61.5% and 88.9% [24]. Ibrahim BZ et al., did CT thorax to diagnose 32 patients with consolidation. Out of these patients LUS was positive in 31 cases and CXR was positive in 5 cases only The sensitivity, specificity, PPV and NPV of LUS was 98.63%, 84.21%, 96%

and 94% and that for CXR was 54.76%, 63.16%, 85% and 26.67% [25].

The results of the present study were also in accordance with these studies as better accuracy of diagnosis was demonstrated (AUC=0.7) with LUS over CXR in early days but, on later days CXR was observed to have better sensitivity, specificity and AUC. In those early days, when CXR and microbiology is not available LUS can help in planning early managing strategies to reduce morbidity and mortality. Abdo-Cuza A et al., have enumerated some of the problems faced with use of LUS other than the unfamiliarity of this radiological imaging tool by anaesthetist. They reported limitations of LUS in diagnosing VAP because of obesity, pleural calcifications and small consolidations <20 mm located posteriorly and around 20% of the lung surface is not visualised by ultrasound due to interposition of the thoracic cage [8].

Generally, in clinical practice antibiotics, antipyretics are empirically started early and hence the clinical parameters became modifiable hence, no statistical significance could be obtained in individual clinical parameters in the study. Similar results were obtained in a meta-analysis sensitivity and specificity of 66.4%, 53.9% for fever, 77% for purulent sputum, 71.1%, 79.6% for Broncho Alveolar Lavage (BAL) and 73.8, 64.4% for CPIS ≥6 [26]. Zhaoquan J et al., also did not find any significant difference in WBC count between VAP and non VAP patients (p.0.05) although the oxygen index was low in patients with VAP and was 171 as compared to 265 in non VAP patients (p<0.05) [27]. Miquel F et al., also like this study, did not find P/F ratio a good marker for VAP diagnosis as >240 ratio did not exclude the disease and <240 P/F ratio had poor association with confirmed microbiological report (odd ratio 0.37 and area under ROC was 0.645) [28] although, many studies or guidelines use P/F ratio routinely as it's an objective variable [2,27].

Alexanndre G et al., in a retrospective cohort study with ROC at 0.74 inferred, that CPIS >7 had more sensitivity and specificity to differentiate between VAT from VAP. CPIS >7 was observed on 8th day in the study and by that time 32 patients were already diagnosed with VAP with all the three modalities [29]. In a recent study, AUC for CPIS with isoprostane and nitric oxide levels in exhaled breath on 5-6 day of ventilation was 0.914. But these techniques although appear to be more accurate, are not available in third world countries like India so cannot be used [27].

Limitation(s)

Patients intubated in the ward ≤48 hours were included in the study as the ICU had six beds only. Predominant patients enrolled in the study were of trauma, who have high chances of silent aspiration and VAP incidence. Quantitative microbiological cultures are not done in the institution hence, qualitative cultures were performed.

CONCLUSION(S)

The LUS was used to diagnosis VAP in the study. With the short learning curve, LUS turned out to be a significant modality with significant diagnostic accuracy in early days, when other parameters were inconclusive. Thus LUS is recommended in ICU for the diagnosis of VAP.

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