Section: Emergency

Original Research Article

ACCURACY AND EFFICIENCY IN DIAGNOSIS AND DISPOSITION OF PNEUMONIA PATIENTS USING BEDSIDE ULTRASONOGRAPHY IN EMERGENCY DEPARTMENT – A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: There is a significant incidence of hospitalization due to community-acquired pneumonia in adults, which is a prevalent and potentially fatal illness. As the most prevalent infectious killer on a global scale, it ranks sixth in terms of mortality rates.

Materials and Methods: This was a prospective, observational, cross-sectional study conducted at the Emergency Department of Mazumdar Shaw Multi Specialty Hospital, Narayana Health City, Bangalore, Karnataka, India. It was a two-year study, specifically from January 2017 to December 2018. The study included all persons (aged over 18 years) exhibiting signs and symptoms of pneumonia.

Results: Out of 60 individuals enrolled in the research, 46 (or 76.67%) were treated for pneumonia. Positive USG results were found in 45(97.83%) of the 46(76.67%) pneumonia patients, while positive CXR results were found in 43(93.47%). Following the completion of the 2×2 table and statistical analysis, we determined that the USG had a sensitivity of 97.83%, a specificity of 92.86%, and PPV and NPV values of 97.83% and 92.86%, respectively. The PPV for CXR was 97.73% and the NPV was 81.25%; the specificity was 92.86% and the sensitivity was 93.48%. Reissig et al. found that LUS had a sensitivity of 93% and a specificity of 98% when it came to diagnosing CAP.[44] Another study by Cortellaro et al. indicated that bedside LUS had a sensitivity of 98%, while CXR had a sensitivity of 67%.

Conclusions: The aforementioned study concludes that patient disposition can be diminished if ultrasound findings are incorporated into the diagnosis.

Key Words: Ultrasound, pneumonia, pneumothorax, diagnosis, disposition.

INTRODUCTION

Community-acquired pneumonia in adults is a common, potentially life-threatening disorder with a high hospitalization rate.[1,2] It is the sixth leading cause of death and the most common infectious cause of death worldwide.[3] Moreover, delay in antibiotic therapy has been associated with an increased risk of death.[3] However, CAP is often misdiagnosed even now. In a retrospective chart review of patients admitted with pneumonia, 22% of patients presented some reason for diagnostic uncertainty that could result in delayed antibiotic delivery.[4] Therefore, a timely diagnosis is mandatory. Early and effective

antibiotic treatment is important. An adequate treatment is thus based on an early diagnosis of pneumonia, yet the diagnosis is not always clear at presentation to the emergency department.

The chest x-ray has its own limitations. It lacks accuracy and has subjective variability. CT chest is the gold standard in diagnosing pneumonia. But CT cannot be done every time. There is a risk of radiation exposure with both chest X-ray and CT scan. Ultrasound is available and most feasible in Emergency departments. It is non-invasive, can be done very easily, and is less time- consuming. Apart from that, it has high sensitivity and specificity.

There are many studies on the usage of Lung Ultrasound in diagnosing many lung pathologies i.e. pneumothorax, pleural effusion, etc. Lung Ultrasound has also been proposed in the diagnosis of pneumonia but is not widely used.

Aim & Objectives

1. To validate the diagnostic accuracy of routine bedside ultrasound for pneumonia.
2. Time to diagnosis, time to patient disposition.

MATERIALS AND METHODS

Methods Study Design

Prospective, observational cross-sectional study.

Venue

Emergency Department of Mazumdar Shaw Multi Specialty Hospital, Narayana Health City, Bangalore, Karnataka.

Study Period

This is a 2-year study i.e. from January 2017 to December 2018.

Inclusion Criteria

All adults (age > 18 years) who present with signs and symptoms of pneumonia.

Exclusion Criteria

Chronic lung disease.

Sample Size

Based on the previous study done by Taghizadieh A et al,[54] the sensitivity of CUS and CXR in the detection of CAP is 85%, the precision 10%, and with a 95% confidence interval the minimum number of diseased subjects in study 60.

Ethical clearance

There are no ethical issues in this study. USG is available in every emergency department and it was used as a routine bedside technique and as a standard of care. We didn't charge for USG. It was prospective cross-sectional study. We have undertaken this study after ethics committee approval i.e. from Mazumdar Shaw Medical Centre, NHHealth City, Bangalore, Karnataka.

Informed consent

Patients who are fulfilling the inclusion criteria were asked to participate in the study and informed consent was taken.

Data collection

Demographic data like age and sex were obtained. Even the time and duration of the presentation were recorded. The patients were evaluated clinically, and history and hemodynamics were noted. A physical examination was done. CXR and USG were done, and findings were recorded. CURB65 and TC were also noted. Time of CXR, USG, and Disposition from arrival were recorded. All the findings were recorded on a predesigned and prepared proforma.

Methodology

The X-ray is performed either in a sitting position or standing position. The ultrasonography is usually performed in lying down position. The visualization of the lungs is better in a sitting position. To prevent the bias both techniques were performed in a sitting position.

A 3.5–5 MHz convex array probe was used. We have seen in intercostal space in the mid- clavicular line, anterior axillary line, mid-axillary line, and para-vertebral line, from the lung apex to the diaphragm. The findings of each image were recorded, like any pulmonary consolidation, focal interstitial pattern, pleural-line abnormalities, and sub-pleural lesions (fig 4.2). CT was considered as the gold standard. If CT was done it would be considered as separate group. If CT was not available, CXR, USG, and clinical parameters together were considered as composite gold standard. But most of the cases whom we have received in an emergency were not subjected to CT scan. The sample size in the second group was negligible, hence we have considered everyone as a single group and recorded the findings which was again subjected to statistical analysis.

(A)

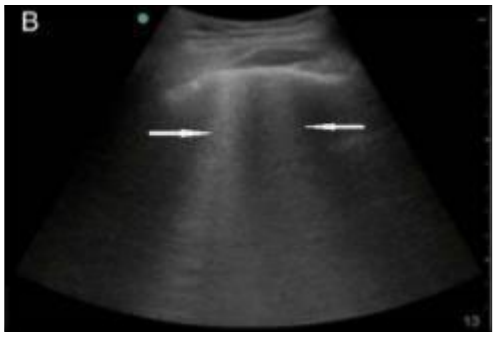
USG machine used in ED

(B)

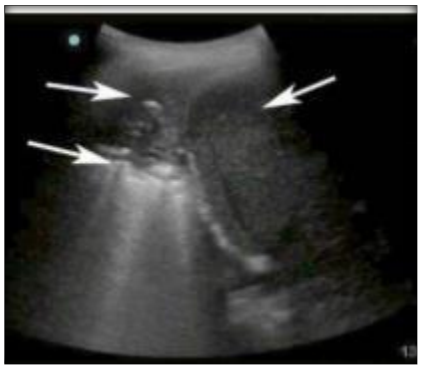
Curvilinear probe of 2-5 MHZ Statistical analysis

Statistical analysis was done using SPSS statistical software 22.0 version. Continuous variables like age and height were explained with average values and

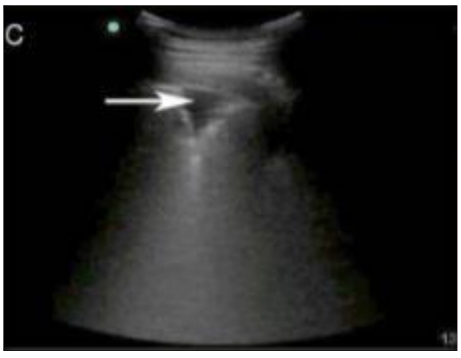
with standard deviations. Categorical variables were explained with frequencies. Accuracy of USG and chest X-ray was assessed by calculating the sensitivity, specificity, predictive values and likelihood ratios. Correlation between CXR and USG was done. The mean time of CXR, USG, and DISPOSITION was calculated.



(A)
Focal interstitial pattern



(B)
Consolidation



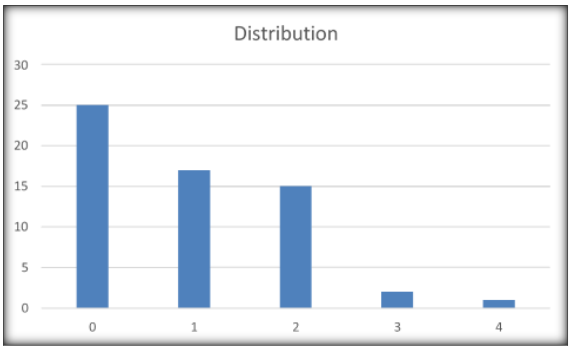
(C)
Sub pleural lesions

(D)
Pleural line lesions

Figure 2: Shows USG findings in pneumonia

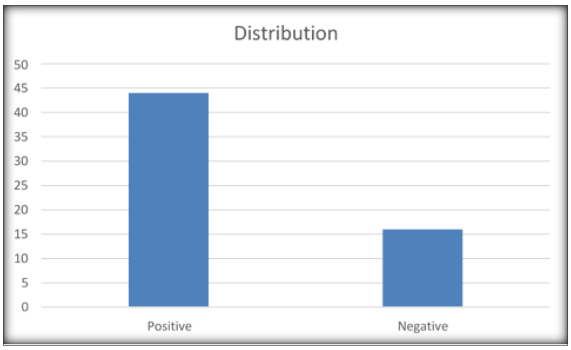
RESULTS

In this study we found that 41.67% of patients had CURB 65 score of zero, 28.33% of patients had score of one. 25%, 3.33% and 1.67% of patients had score of 2, 3 and 4 respectively. [Table 2]



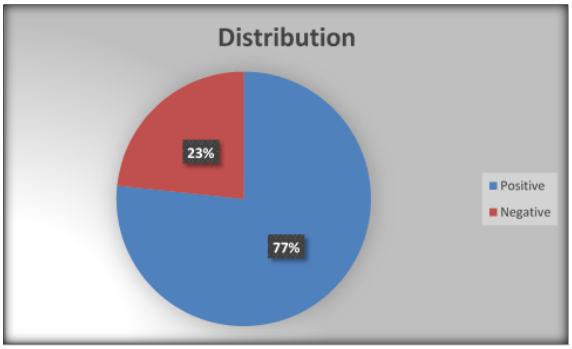
Graph 1: Distribution of patients and their CURB score

In our study, we had 73.33% of patients had positive CXR findings and only 26.67% had negative CXR findings. This graph and table represents CXR findings irrespective of pneumonia present or absent.



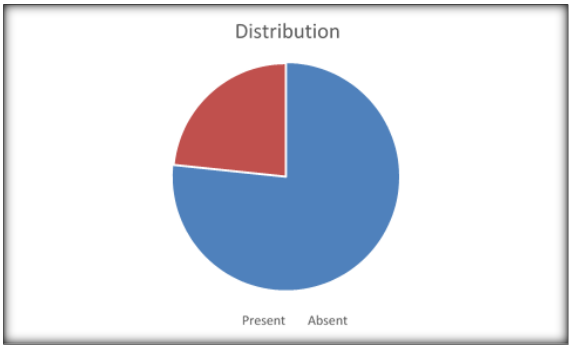
Graph 2: Distribution according to CXR findings

In our study, 76.67% of patients had positive USG findings, and only 23.33% had negative USG findings. This graph and table represent USG findings irrespective of pneumonia present or absent.



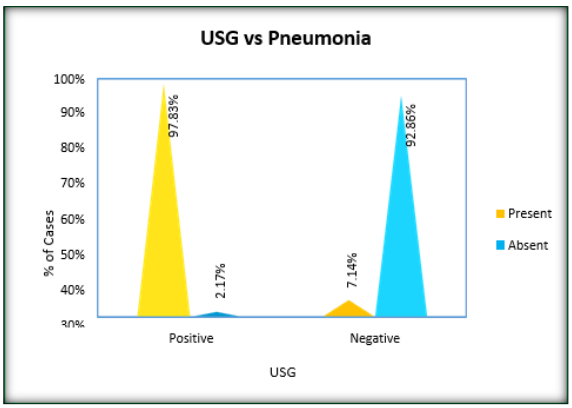
Graph 3: Number of patients with positive USG findings

In this study, we had 76.67% patients who were diagnosed and treated as pneumonia and 23.33% patients were not diagnosed and treated as pneumonia



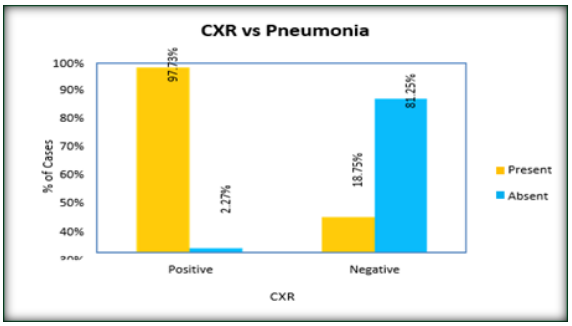
Graph 4: Number of patients treated as pneumonia

In this study we found that among 46 patients who diagnosed with pneumonia, 45 patients had positive USG findings (TP) and 1 patient had negative USG findings (FP). Among 14 patients of who was not diagnosed with pneumonia, 13 patients didn't have any USG findings (TN) and 1 patient had positive USG findings (FN).



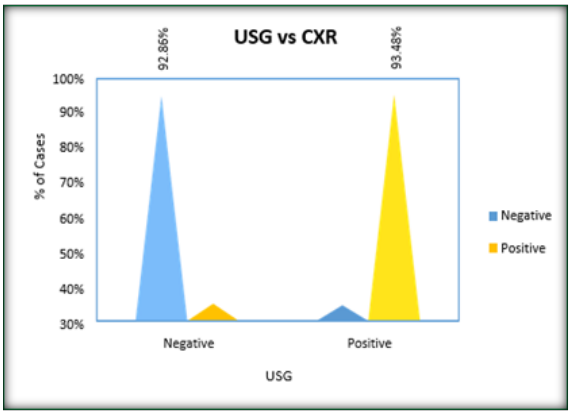
Graph 5: Percentage of pneumonia patients and their USG findings

In this study we found that among 46 patients who diagnosed with pneumonia, 43 patients had positive CXR findings (TP) and 3 patients had negative CXR findings (FP). Among 14 patients of who was not diagnosed with pneumonia, 13 patients didn't have any CXR findings (TN) and 1 patient had positive CXR findings (FN).



Graph 6. Percentage of pneumonia patients and their CXR findings

In this study we have done a comparison between CXR and USG findings. We found that 43 patients of pneumonia had both CXR and USG positive findings and 13 patients had both CXR and USG negative findings. Using Chi-Square test, we got the P-Value which is <0.001



Graph 7. Represents percentage of patients with respect with CXR and USG findings

The above table and graph represent the same correlation but in percentages. 93.48% of patients had both CXR and USG positive findings and 92.86% of patients had both negative findings. 7.14% of CXR positive patients had negative USG findings. 6.52% of USG positive patients had negative CXR findings. The above table represents the correlation between CXR and USG using measure of agreement using KAPPA. 0 value indicates no correlation and 1 value indicates correlation. Our value is close to 1 hence it was significant. Therefore, USG findings are correlating with CXR findings.

In this study we have noted that the mean time required for CXR from arrival was 65.82min with min of 20min and max of 200min. the mean time of USG from arrival was 31.57 min with min of 15min and max of 70 min. [Table 10]

Table 1: Demographic details of patients

Age	Distribution(N=60)	Percentage
< 35	15	25.00%
35 - 50	15	25.00%
50 & Above	30	50.00%
Time of Presentation		
8AM - 2PM	23	38.33%
2PM - 8PM	20	33.33%
8PM - 8AM	17	28.33%
Month of Presentation		
Q1	7	11.67%
Q2	7	11.67%
Q3	33	55.00%
Q4	13	21.67%
Presenting Complaints		
Fever	47	78.33%
Cough	45	75.00%
Breathlessness	36	60.00%
Hemoptysis	5	8.33%
Other	9	15.00%
Duration		
< 3Days	15	25.00%
3 days - 6 Days	31	51.67%
7 Days & Above	14	23.33%

Table 2: Vital signs of the patients included in the study

Heart Rate	Distribution(N=60)	Percentage
<= 100	23	38.33%
101+	37	61.67%
Respiratory Rate		
<= 18	9	15.00%
19+	51	85.00%
SpO2		
<= 75%	10	16.67%
75% - 85%	11	18.33%
85% - 95%	27	45.00%
Above 95%	12	20.00%
Total Count		
< 4	2	3.33%
4 - 10	33	55.00%
11 & above	25	41.67%

Table 3: Distribution of patients and their CURB score

CURB65	Distribution(N=60)	Percentage
0	25	41.67%
1	17	28.33%
2	15	25.00%
3	2	3.33%
4	1	1.67%
Total	60	100%

Table 4: Distribution according to CXR findings

CXR	Distribution(N=60)	Percentage
Positive	44	73.33%
Negative	16	26.67%
Total	60	100%

Table 5: Number of patients with positive USG findings

USG	Distribution(N=60)	Percentage
Positive	46	76.67%
Negative	14	23.33%
Total	60	100%

Table 6: Number of patients treated as pneumonia

Pneumonia	Distribution(N=60)	Percentage
Present	46	76.67%
Absent	14	23.33%
Total	60	100%

Table 7: Table of 2×2 showing USG findings and pneumonia

	Pneumonia Distribution(N=60)		
USG			**Total**
	Present	**Absent**	
Positive	45((97.83%)	1(2.17%)	46
Negative	1(7.14%)	13(92.86%)	14
Total	46	14	60

SENSITIVITY = (TP/ TP+FN) ×100
= (45/45+1) ×100
= 97.83%
SPECIFICITY = (TN/TN+FP) ×100
= (13/13+1) × 100
= 92.86%
POSITIVE PREDICTIVE VALUE = (TP/TP+FP) × 100
= (45/45+1) × 100
= 97.83%
NEGATIVE PREDICTIVE VALUE = (TN/TN+FN) × 100(13/13+1) × 100
= 92.86%
We found that 97.83% of pneumonia patients had positive USG findings which represents the sensitivity of USG. 92.86% of patients found no USG findings and no pneumonia which represents specificity of USG. We found 7.14% of pneumonia patients had negative USG findings and 2.17% of no pneumonia patients had positive USG findings.
Hence from the above findings, the following statistical analysis has been done

Sensitivity	97.83%
Specificity	92.86%
PPV	97.83%
NPV	92.86%
Likelihood ratio positive	13.69565217
Likelihood ratio negative	0.023411371

Table 8: Table of 2×2 showing CXR findings and pneumonia

	Pneumonia Distribution(N=60)		
CXR			**Total**
	Present	**Absent**	
Positive	43(97.73%)	1(2.27%)	44
Negative	3(18.75%)	13(81.25%)	16
Total	46	14	60

SENSITIVITY = (TP/ TP+FN) ×100
= (43/43+3) ×100
= 93.48%
SPECIFICITY = (TN/TN+FP) ×100
= (13/13+1) × 100
= 92.86%
POSITIVE PREDICTIVE VALUE = (TP/TP+FP) × 100
= (43/43+1) × 100
= 97.73%
NEGATIVE PREDICTIVE VALUE = (TN/TN+FN) × 100(13/13+3) × 100
= 81.25%
We found that 97.73% of pneumonia patients had positive CXR findings which represents the sensitivity of CXR. 81.25% of patients found no CXR findings and no pneumonia which represents specificity of CXR. We found 18.75% of pneumonia patients had negative CXR findings and 2.27% of no pneumonia patients had positive CXR findings.
Hence from the above findings, the following statistical analysis has been done

Sensitivity	93.48%
Specificity	92.86%
PPV	97.73%
NPV	81.25%
Likelihood ratio positive	13.08695652
Likelihood ratio negative	0.070234114

Table 9: Comparison of patients according to both CXR and USG findings

CXR Distribution(N=60) with percentages			
USG	**Negative**	**Positive**	**Total**
Negative	13(92.86%)	1(7.14%)	14
Positive	3(6.52%)	43(93.48%)	46
Total	16	44	60

Table 10: Statistical correlation between CXR and USG

Symmetric Measures Distribution(N=60)					
		Value	**Asymp. Std. Error**	**Approx. Tb**	**Approx. Sig.**
Measure of Agreement	Kappa	.822	.085	6.396	0.000
N of Valid Cases		60			

Table 11: Statistics representing time of CXR, USG and Disposition from arrival

Time of X-Ray fromarrival		**Time of USG from arrival**	**Time of disposition from arrival**
Valid	60	60	60
N			
Missingg	0	0	0
Mean	65.82	31.57	109.32
Median	60.00	30.00	94.50
SD	31.977	13.714	44.557
Minimum	20	15	33
Maximum	200	70	240

DISCUSSION

Community-acquired pneumonia one of the most common presentations in adults especially in elderly people. It has high hospital admission rate and mortality is high among these patients. It is sixth leading cause of death in world. Early diagnosis and treatment may help to reduce the risk of death. Patients who present to emergency with pneumonia may have a varying presentation and severity.

Even URTI patients may have similar presentation and symptoms, differentiation plays important role to start early management and better prognosis. Administration of antibiotics and supportive management is main stay of treatment in pneumonia to reduce the mortality.

The main diagnostic technique for pneumonia is radiological entities like X ray and CT scan. CXR is being used primarily in the diagnosis and CT scan is being like gold standard technique. Chest x ray is the 1st technique. It is subjective and time consuming. Risk of radiation is also more with CXR.

Ultrasound in the diagnosis of lung pathologies has increased its value. It is important diagnostic modality available in EMERGENCY to diagnose various cases and also to perform many procedures. It has already proven its importance in the diagnosis of pleural effusion, pneumothorax. It is free of cost as it is a bedside technique, fast noninvasive.

There are many studies done on USG in the diagnosis of pneumonia. This study was undertaken to prove that USG can be helpful in the diagnosis of pneumonia in emergency with minimal training, so that we fasten up the administration of antibiotics and disposition can be done fast.

The current study was prospective observational cross-sectional study done in Department of Emergency medicine, Mazumdar Shaw Medical Center, NH Health city, Bangalore. According to the previous study my sample size is 49, because of more presentation to the department this was conducted on 60 patients from January 2017 to December 2018.

In the present study, incidence was more in males compared to females. 53.33% of males had been affected. The ratio of male to female is 1.14:1 which almost equal incidence. In a study by Lamoth et al, it was found that males had more incidence than females.[9]

In this study we found that, incidence was more in age group of age > 50years with percentage of 50%. The percentage of people below 35years was 25% and between 35- 50years was also 25%. In a study by kung HC et al, incidence increases with age and mortality is more in elderly aged group.[11]

We also found in this study that incidence of the disease was more in 3rd quarter of the year i.e. 55% and later in 4th quarter. 51.67% of patients presented to ER within 3-6 days of illness and 25% patients presented with in 3days. Rest of the patients greater than 7 days. Pneumonia had a seasonal variation; our study had proven it. The reason for seasonal variation could be, the higher incidence of viral infections like influenza in that period. In a study by Jain et al, they found that viruses were second most common cause of pneumonia.[8] We also noticed that presentation to ED was higher in morning. period. It may not carry much importance to describe.

In this study, we noticed that most of the patients presented to emergency with symptoms of fever (78.33%), cough (75%) and breathlessness (60%). There were some nonspecific symptoms like vomiting, generalized weakness nausea. Hemoptysis was also noted but less in number i.e. 8.33%. In astudy by Mufson MA et al, most common symptoms are fever and breathlessness,[12] Hemodynamic parameters were also studied in this study, 37

patients, 61.67% found to have tachycardia greater than 100bpm. 51 patients i.e. 85% were tachypneic, RR greater than 18cycles per min. most of the patients, 45% maintained Spo2 between 85-95%. Spo2 less than 75% was seen in 16.67% patients. At the time presentation to ER, most of the patients didn't have raised temperature like 63.33% patients noticed to have normal or below normal temperature. In study by Mufson MA et al, patients had either tachycardia (100) or bradycardia (60) and tachypnea (>18).[13]

In present study, we also studied about CURB65. We found that maximum patients like 41.67% had score of 0. 28.33%, 25%, 3.33% and 1.67% patients had score of 1, 2, 3 and 4 respectively. In a study by C. Armi˜nanzas et al, they studied about CURB65 and said that it indicates the severity of pneumonia. It also used for sign for hospital admission. Recent studies proved that, CURB65 doesn't hold importance in severity of disease. It will give false positive or negative results. In our study also we have noticed that many patients who were really sick and needed ICU admission had found to have score 0 or 1. Hence it was proven CURB65 cannot be used to decide about severity and hospital admission.[14]

In this study we have studied about Infective parameters like total counts (TC). More than half of the patients, 55% had normal counts (4-11). Only 41.67% patients counts greater than 11. Only 2 patients had less than 4. In study by C. Armi˜nanzas et al, there could be leukocytosis or leucopenia.[15]

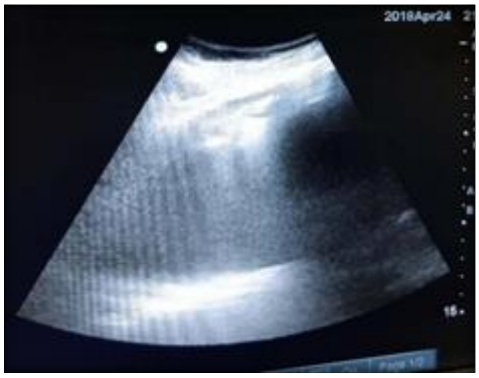
In this study, coming to main part that was CXR vs USG in the diagnosis of pneumonia. Performing x-ray to a patient presented to hospital with signs and symptoms of pneumonia is a routine practice. Findings with respect to x-ray were haziness, increased bronchoalveolar markings or complications of pneumonia (effusion, empyema). So, in USG we find the consolidation, focal interstitial pattern, subpleural lesions and pleural line abnormalities.[16]

The same was mentioned in methodology. In our study also we have observed the same findings like air bronchograms (consolidation) and B-lines (focal interstitial pattern) we couldn't find pleural findings in much patients. We have considered CT as a gold standard in this study but unfortunately only few patients underwent CT in EMERGENCY.[17]

In this study, the distribution of patients with findings of USG were tabulated below.

If we have observed from the above table, most of the patients were noticed to have air bronchograms i.e. 36.67% and 30% of patients had B lines, 11.67% had both bronchograms and B lines. May be from this we could believe the most common USG finding in pneumonia would be CONSOLIDATION (AIRBRONCHOGRAMS). One important was dynamic air bronchograms was specific to pneumonia because static bronchograms were common in collapse. We have seen in one patient where x-ray was showing haziness and USG showed static air bronchograms and CT was done showing that patient had a collapse lung, so DYNAMIC AIRBRONCHOGRAMS were specific for pneumonia. [Table 12]

Pneumonia had 4 stages of presentation. They are CONGESTION (1st day), RED HEPATIZATION (2-4days), GREY HEPATIZATION (5 8days) and RESOLUTION (above 8 days). Here we were describing the USG findings with duration of illness.[18] We have noticed that patients who presented with in 3days had more of B lines which may indicate congestion phase where more exudates present in the lung and it may be described as INTERSTITIAL PATTERN. The following figure may indicate it. [Table 13]



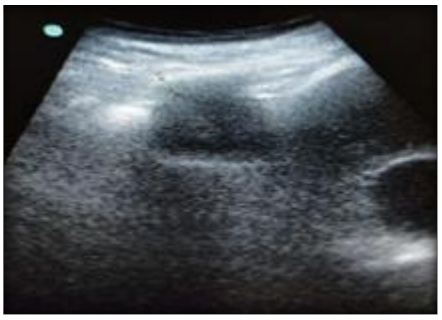
(A)
B-lines – INTERSTITAL PATTERN

(B)
Bronchograms-CONSOLIDATION

Figure 3: USG findings of pneumonia seen in this study

Patients who presented >3days may be in hepatization phase (liver like texture). Out of 24 patients with positive patients 14 had bronchograms and out of 13 patients who presented 7days and above 11 had bronchograms. It indicates hepatization phase may be seen as consolidation (AIRBRONCHOGRAMS). This was interesting that USG findings may change with pathological changes of pneumonia.

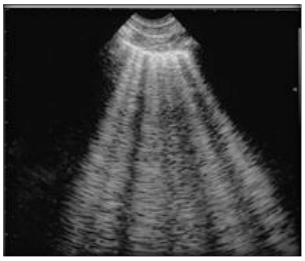
(A)



(B)

Figure 4: Patient treated as pneumonia with CXR and USG findings

CXR showing only increased bronchoalveolar markings in right lower zone and B- air bronchograms on USG.



(A)

(B)

(C)

(D)

Figure 5: CXR, USG and CT scan findings in a patient of pneumonia

In the above figure we mentioned regarding one patient who presented with one day of symptom onset. USG done showing extensive B lines (A) and CXR showing right Broncho pneumonia(C) and CT scan showing pneumonia (B, D)

In case of complications of pneumonia like pleural effusion, CXR may only show effusion but USG might show underlying consolidation also.

(A)

AIR BRONCHOGRAMS underlying

(B)

CXR showing only pleural effusion Pleural effusion

Figure 6: CXR and USG findings in a patient with complications of pneumonia

We have conducted a study on 60 patients, out of them 46 patients were treated as pneumonia i.e. 76.67% of patients. In 46(76.67%) patients of pneumonia 45(97.83%) had positive USG findings and 43(93.47%) had positive CXR findings.

After doing statistical analysis after constructing 2×2 table, we have got the sensitivity of USG was 97.83%, specificity was 92.86% with PPV and NPV was 97.83% and 92.86%. For CXR sensitivity was 93.48%, specificity was 92.86% with PPV and NPV was 97.73% and 81.25% respectively. In a study done by Reissig et al, LUS was 93% sensitive and 98% specific in diagnosing CAP. [44] In another study done by Cortellaro et al LUS which is done on bed side

was found to have 98% sensitivity compared with only 67% sensitivity for CXR.[19]

There were two meta-analysis done by Hu et al and Chavez et al, In their studies the sensitivity and specificity are (97% and 94%) and (94%and 96%). A study by See et al, proved no need of extensive training to perform a basic bedside LUS.[20]

We have done correlation of CXR and USG in this study, we have found 43patients (93.48%) had both USG and CXR positive findings and 13 patients (92.86%) had both negative findings. We noticed there was a significant relation between them with p value <0.001(chi-square test). And using measurement of agreement, KAPPA we found that it was 0.82 and it was again significant. A study done by Liu et al, the p valuewas <0.001.[21]

We also done time of CXR and USG from arrival, so that we base our treatment on USG. We found that mean time for USG was 31.57min and for CXR was 65.82min and it was proved significant with p value <0.001(t paired test). The minimum time for USG was 15min and for CXR was 20min. The disposition mean time 109.32min from arrival. Therefore, if we consider the USG as diagnostic technique, we can reduce the disposition time of the patient.[22]

CONCLUSION

Ultrasonography is more sensitive than chest x-ray in the diagnosis of pneumonia. It is also more specific than x-ray. The mean time for USG is 31.57min with min of 15min and mean time for CXR is 65.82min with min of 20min. Disposition of patient can be reduced if USG findings were considered in the diagnosis.

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