International Journal of Research in Medical Sciences
Rennis KD et al. Int J Res Med Sci. 2017 Jan;5(1):25-30
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: http://dx.doi.org/10.18203/2320-6012.ijrms20164510

Original Research Article

Role of chest ultrasonography in the prognostic evaluation of patients with community acquired pneumonia: a prospective study

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Received: 05 December 2016
Accepted: 10 December 2016

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ABSTRACT

Background: Chest ultrasonography (USG) has shown a growing interest during the last few years in the diagnosis of pneumothorax, pneumonia, or pulmonary contusions. This study was aimed to assess the ability of bedside chest USG in the prognosis of community-acquired pneumonia (CAP) patients and to compare USG with pneumonia severity index (PSI) score and conventional chest radiograph (CXR).
Methods: This prospective study was done in patients who get admitted with history and examination findings suggestive of community-acquired pneumonia were included in the study, PSI scoring and CXR were evaluated at the time of presentation. Chest physician performed the thoracic USG. PSI scoring, CXR and USG were repeated on third day and at the time of final outcome. Diagnosis at hospital discharge was taken as the reference standard.
Results: Total 100 patients (57±17 years) were included in the study. Correlation between USG, CXR and PSI score were analysed using Spearman's correlation (r). A significant (p = 0.001) correlation between USG and PSI score was found on day 1 (r=0.35), on day 3 (r=0.43) and on the final day (r=0.25). Similarly a significant correlation (p=0.001) was also found between USG and CXR (on day1(r=0.81), on day 3 (r=0.81) and on final day (r=0.74).
Conclusions: The chest-ultrasound as a bedside real time, reliable, rapid and non-invasive technique is useful in the prognostic evaluation of pneumonia patients.

Keywords: Chest X-ray, Community-acquired pneumonia, Pneumonia, PSI score, Ultrasonography

INTRODUCTION

Community-acquired pneumonia (CAP) is one of the commonest diseases plaguing the human race, affecting approximately 450 million people per year and occurring in all parts of the world.[1,2] Despite that, pneumonia can be diagnosed by history and physical examination findings, diagnosis has recently become highly dependent on imaging. Currently chest X-ray (CXR) is recommended for the routine evaluation of the patient suspected of having pneumonia, despite its low sensitivity and specificity. In an appropriate clinical setting, diagnosis of pneumonia is established in the case of a new infiltrate on a chest radiograph.[3] CXR is associated with considerable practical delays related to processing.[4] Because of the methodological limitation of a chest radiograph, Computed tomogram (CT) imaging is regarded as the gold standard for the diagnosis of pneumonia with a higher sensitivity and specificity.[3] However, CT scan may not always be available and is charged with a high radiation dose and high cost that precludes its use in the routine diagnostic and follow-up process of patients with suspected pneumonia.[5,6] The pneumonia severity index [PSI] or Pneumonia Patient

Outcomes Research Team (PORT) Score is a clinical prediction rule that can be used to assess the probability of morbidity and mortality among patients with pneumonia.[7,8]

Chest USG has shown a growing interest during the last few years in the diagnosis of pneumothorax, pneumonia, or pulmonary contusions.[9] In addition to chest radiography and CT chest, USG represents an imaging technique for identifying pneumonic lesions, and thus provides an additional tool for diagnosing pneumonia. Previous studies were demonstrated a significantly higher sensitivity of lung ultrasound for the diagnosis of acute pneumonia compared to chest X-ray.[10,11] The use of bedside lung ultrasound in the assessment of alveolar interstitial syndrome was reported previously.[12] However, little is known about whether it can also be used in follow-up of pneumonia. Hence this study was aimed to assess the ability of bedside lung USG in the prognosis of patients with CAP and to compare USG with PSI score and conventional chest radiograph.

METHODS

Prospective observational study was conducted in patients admitted with clinical suspicion of community acquired pneumonia in the Department of Pulmonary medicine, Amala Institute of Medical sciences, Thrissur during the period of January, 2013 to December, 2013. All the patients (age more than 12 years) who were admitted with signs and symptoms of community-acquired pneumonia as per the standard criteria were included in the study.[7,13-15] Out patients with signs and symptoms of pneumonia, those with less than 3 days hospital stay, patients with mechanical ventilator support within 3 days of admission, pregnant women and children of <12 years age, pneumonia other than CAP and patients not willing to participate in study were excluded from the study. Informed consent was obtained from all the patients or their relatives included in the study and the study was carried out after the approval of Institutional Research and Ethics Committee Approval.

Study procedure

Clinical history including symptoms, co-morbidities and risk factors were documented. Systematic clinical examination was done. In patients admitted with history and examination suggestive of pneumonia, PSI scoring will be determined and chest radiography was taken at the time of presentation.

Chest physician (trained in trans-thoracic ultrasound) performed the chest ultrasound examination. Expert opinion in certain cases was obtained from the radiologist. Follow-up of all the patients included in the study was carried out till the discharge. PSI scoring, chest radiography and chest ultrasound were repeated on third day and at the time of final outcome (recovery or mechanical ventilatory assistance) for all the patients to assess usefulness in the prognosis. Diagnosis at hospital discharge was taken as the reference standard.

Pneumonia severity index (PSI)

PSI was calculated by using clinical history, vital signs, laboratory and ABG investigations (Table 1 and 2).

Chest X-ray

All patients underwent posterior-anterior (PA) and lateral chest radiography on admission. Each patient able to maintain orthostatic position undergo PA radiograph with a fixed machine (DR machine-Definium 6000/CR machine Siemens). If patient because of his clinical condition cannot move to the radiology ward, CXR was taken using a portable device. CXR (PA view) divided into 3 zones in each hemi thorax (total 6 zones). Scoring done depends on involvement of pneumonic infiltrates, 6 scores for 6 zones.

Chest ultrasonogram

All ultrasounds were performed at the bedside by a single expert physician. Sonographic investigation conduct using 5MHz convex probe and supplement by examination with a color flow Doppler mode (LOGIQ-e – portable). Examination by a 7.5 MHz linear probe was occasionally performed. Patients were examined anteriorly in a supine position and the posterior areas were studied in the lateral decubitus or sitting position according to clinical status. A systematic examination of all intercostal spaces was performed.[16,17]

In agreement with literature each hemi thorax is divided into 5 areas- 2 anterior, 2 lateral and 1 posterior (Total of 10 areas).[18,19] The anterior chest wall is marked off from parasternal line to anterior axillary line. This zone is split into upper region (from clavicle to the second-third intercostals space) and a lower region (from the third intercostal space to diaphragm). The lateral area from anterior to posterior axillary line is divided into upper and lower halves. Posterior zone from the posterior axillary line to the paravertebral line raising the arm above the patient's head increases the rib space distance and facilitates scanning. Scanning was performed during quiet respiration, to allow for assessment of normal lung movement, and in suspended respiration, when a lesion can be examined in detail. The echogenicity of a lesion was compared with that of the liver and characterized as hypoechoic, isoechoic, or hyperechoic.

The ribs on longitudinal scan appear as curvilinear structures associated with post acoustic shadowing. Pleura looks like an echogenic line, showing a continuous intrinsic movement during breathing called 'lung sliding sign'. The air filled lung parenchyma prevents any further echogenic visualization under pleural line. However the wide acoustic impedance difference between pleura and the underlying parenchyma creates typical horizontal

artefacts. These are a series of echogenic parallel line equidistant to one another arising from the pleural line. These artifacts were defined A lines by Lichtenstein. Other vertically oriented 'comet tail' artifacts (B lines) according to Lichtenstein et al might be present. B lines arise from pleura-lung interface, reach the edge of the screen, erase A lines, move with lung sliding and are absent in the normal lung. These artefacts result from the fluid rich sub pleural interlobular septae that, surrounded by air.

Criterion to determine the ultrasonographic diagnosis of pneumonia is the finding of sub-pleural lung consolidation with evidence of static or dynamic air bronchogram. Sonography was assessed for the location, shape, size, and breath-dependant movement of pneumonia. Furthermore, the incidence of positive air bronchogram, fluid bronchogram, as well as local and/or basal pleural effusion was assesed on day 1, day 3 and on the day of final outcome. Total 10 scores given to 10 areas depend on the area of involvement.

The severity of pneumonia by PSI scoring will be compared with zonal involvement by chest radiograph and areas involved by lung USG at the time of presentation, on 3rd day and at time of recovery or final outcome

Statistical analysis

Continuous variables were expressed as means ± standard deviation (SD) and categorical data as numbers and percentages. Relationship between PSI, CXR and USG scores was checked by using Spearman's rank correlation (SPSS, v16, IBM, CA, USA). Agreement between CXR and USG was assessed by kappa value. P value <0.05 was considered as significant.

RESULTS

CAP was diagnosed in 100 patients (ages ranged from 15 to 83 years) with a mean age was 57±17 years. Among the total patients 59% were males and 48% were smokers. Cough was the most common presentation (98%). Diabetes and hypertension was the most frequent co-morbidities (30%). History of coronary artery disease was found in 22% and 23% had history of COPD. Mean duration of hospital stay was 9±4 days, whereas 55% of patients hospitalized between 6-10 days. Right side pneumonia was found in 49% patients had and 15% had bilateral pneumonia.

During admission 52% patients in PSI class 5, 30% patients in class 4 and 11% patients in class 3. On final day of assessment 10% patients in class 5, 16% patients in class 4, 20%patients in class 3 and 38% patients in class 2. Mechanical ventillatory support were used in 8 patients and 2 patients died. Chest X-ray had consolidation in all the patients during the time of admission predominantly involving lower zone.

Table 1: Pneumonia severity index score.

		Points
Age		Age (years)
Female		(-10)
Nursing house residency		10
Co morbidity	Neoplastic	30
	Liver disease	20
	CCF	10
	CVA	10
	Renal disease	10
Vital signs	Mental confusion	20
	RR >30	20
	Syst. BP <90 mmHg	20
	Temp ≥40°C/<35°C	15
	Tachycardia ≥125 bpm	10
Laboratory abnormalities	BUN ≥11mmol/L	20
	Na+ <130 mmol/L	20
	Glucose ≥250 mg/dl	10
	Haematocrit <30%	10
Radiological	Pleural effusion	10
Oxygenation	Art pH <7.35	30
	PaO2 <60 mmHg/ SaO2 <90 mmHg	10

Table 2: Pneumonia severity index – Class.

Class I	**<50 year and No co morbidity**
Class II	<70 points
Class III	71-90 Points
Class IV	90-130 points
Class V -	>130 Points

Table 3: Ultrasonography features.

	At the time of admission (%)	At the time of final outcome (%)
Hypoechoic areas of varying size & shape	92	39
Irregular and serrated margins	43	22
Dynamic air bronchogram	92	39
Hepatisation of lung tissue	30	3
Fluid bronchogram	7	1
Pleural effusion	29	2

USG showed features of consolidation in 92% patients, predominantly involving posterior and lower lateral areas. Of patients with sonographically detected pneumonia, dynamic air bronchogram was present. Hepatisation of lung tissue detected in 30% and irregular and serrated margins in 43% of patients. Pleural effusion

was evident in 29% of patients. Disease remission was demonstrated sonographically. The proportion of patients with an air bronchogram decreased from 92% to 39% of patients (Table 3). CXR was normal in 41% patients and ≥5 score in 2% patients during the time of final assessment. USG was normal in 61 % patients and >8 score in 2% patients during the time of final assessment. In total 100 patients pleural effusion detected by both CXR and USG in 13 patients and by USG alone in 16 more patients.

Table 4: Correlation between pneumonia severity index (PSI), chest ultrasonography (USG) and chest radiograph (CXR) scores.

	PSI and USG		PSI and CXR		USG and CXR	
	Correlation coefficient	P value	Correlation coefficient	P value	Correlation coefficient	P value
Day 1	0.351	0.001	0.32	0.001	0.85	0.0001
Day 3	0.430	0.001	0.4	0.002	0.812	0.0001
Final day	0.25	0.012	0.32	0.0018	0.74	0.0001

Table 5: Agreement between chest ultrasonography (USG) and chest radiograph (CXR) findings on the final day.

CXR	USG findings			Kappa
	Normal	Abnormal	Total	
Normal	40	1	41	0.55**
Abnormal	21	38	59	
Total	61	39	100	

**P = 0.01.

Since the PSI, USG and CXR scores were ordinal measurements, non-parametric methods were applied. Average scores at three days were explained by median and range. Relationship between three scores was checked by using Spearman's rank correlation (r). A significant correlation between USG and PSI score was found on day1 (r=0.35), on day 3 (r=0.43), and on final day (r=0.25) which were significant at 0.001 level. A significant correlation was also found between USG and CXR on day1 (r=0.81), on day 3 (r=0.81) and on final day (r=0.74) which were significant at 0.001 level (Table 4). There was good agreement between CXR and USG (kappa value>0.55) which was significant at 0.01 level (Table 5).

DISCUSSION

The use of chest ultrasound in the evaluation of pneumonia is growing rapidly and in each clinical setting shows increased efficiency. Chest ultrasound can substantially decrease the practical delays associated with CXR and avoiding radiation exposure. However, the execution of USG examination is strictly dependent on the operator experience; the echographic image interpretation itself is definitely less dependent on the operator. The ultrasound pattern of a lung consolidation is indeed completely different from an alveolar-interstitial syndrome or a normal pattern.[20]

In present prospective observational study, CAP was in mean age of 57 years, with male predominance. This can be explained by the fact that pneumonia in old age has high incidence and is related to co-morbidities. Other studies were also support this findings.[21-23] During admission 52% patients in PSI class 5. Mechanical ventillatory support was used in 8 patients. These all 8 patients with worsening of pneumonia in class 5 during admission. Worsening and improvement of pneumonia were detected by using both CXR and USG in present study. But CXR needs transportation to radiology room and repeated radiation exposure.

In about 8% of patients, CAP was not able to be detected by USG, because ultrasound performance is probably very good at detecting superficial pneumonia, it remains however poor at detecting deep alveolar lesions. This is in good accordance with other studies.[10,24-26] Disease remission also demonstrated sonographically in present study. On follow-up, parenchymal pneumonic lesions decreased both in size and lost their echotexture intensity or even disappeared. Study of Koregel et al observed that in 91% of the pneumonic lesions, a decrease or disappearance of the hypoechoic, irregularly shaped parenchymal lesion, as measured by length and height as well as circumference and area of infiltration.[24]

Present study results show a significant correlation between USG, PSI and CXR on third day and the day of final outcome. Correlation between USG and CXR were more significant than correlation between USG and PSI. Sonographic follow-up of pneumonia allows for rapid therapeutic decision. Chest ultrasound offers important role in CAP, especially if CXR is not available and in immobilised patients.

Non-invasivity is a striking quality of this technique, especially concerning its use in children, pregnant women for the follow-up of lung lesions. Radiation exposures on serial CXR can further be avoided if an alternative tool like USG is available bedside.

The main limitation of this study was the less number of patients enrolled; however, statistical analysis shows significant results, favourable to lung USG. This study was restricted to inpatients with suspicion of CAP. However, it is assumed that the results are comparable to outpatients. Patients suffering from hospital-acquired pneumonia and immunodeficiency were excluded because it is assumed that sonomorphology in these cases may differ.

Therefore, these conclusions exclusively refer to CAP. Although ultrasound diagnosis was established on the basis of objective signs, there are no studies documenting what level of proficiency is necessary for a reliable ultrasound diagnosis of pneumonia. More studies on indication of chest USG are required for characterizing the ultrasound findings and its interpretation.

CONCLUSION

This study supports the use of chest-ultrasound in prognostic evaluation of community acquired pneumonia patients, as it is bedside real time, reliable, rapid, and non-invasive technique. Further, it could be an effective tool for pneumonia patients' management.

ACKNOWLEDGEMENTS

Authors would like to thank Dr. Ajith TA, Professor of Biochemistry, Department of Biochemistry, Amala Institute of Medical Sciences; Thrissur, Kerala, India during the preparation of the manuscript.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Rennis KD, Anaz M, Krishnakumar EV, Thomas V, Robert AP. Role of chest ultrasonography in the prognostic evaluation of patients with community acquired pneumonia: a prospective study. Int J Res Med Sci 2017;5:25-30.