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ORIGINAL ARTICLE

The utility of lung ultrasound in evaluation of infants with suspected bronchiolitis

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KEYWORDS

Lung ultrasound;
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Abstract *Aims:* To study the role of lung ultrasound (LUS) in the evaluation of bronchiolitis in infants.
Patients and methods: 25 hospitalized infants, their mean age (6.94 ± 4.48 months), 7 males and 18 females. All patients underwent chest X-ray (CXR) and lung ultrasound after full clinical examination with suspicion of bronchiolitis and evaluation for corresponding findings.
Results: In 25 infants suspected clinically to have bronchiolitis, 11 patients had mild degree of bronchiolitis, other 11 patients had moderate degree and only 3 cases had severe form of bronchiolitis. The chest X-ray and lung ultrasound were done for all patients; the chest X-ray findings were non-specific including lung plethora in 6 patients, hyperinflation in 3 patients and peribronchial thickenings in 1 patient. The lung ultrasound findings were significant and variable ranged from subpleural lung consolidation in 3 cases, compact B-lines in 6 cases, pleural line abnormalities (thickening and irregularity) in 8 cases and small isolated B-lines in 11 cases. On follow-up of infants, the lung ultrasound findings were correlated positively with the clinical course of the disease.
Conclusions: Lung ultrasound played an important role in the diagnosis, management and follow-up of infants with clinical suspicion of bronchiolitis.

1. Introduction

The normal lung is formed mainly of air and ultrasound waves completely reflected without being translated into an image. The only visible structure in the normal lung is the pleura (1). The ultrasound beam can access to the lung parenchyma when the infectious process infiltrates it and replaces the

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alveolar air contents, then the lung appears similar to other parenchymal organs (2).

Bronchiolitis patho-physiologically is characterized by edema, increased production of mucous and necrosis of infected epithelial cells of small airways that cause obstruction to distal bronchioles leading to reduced air contents in the lung and so ventilation-perfusion inconsistency (3). The diagnosis of bronchiolitis should be made on the basis of medical history and clinical examination (4).

The routine use of chest radiograph for the diagnosis of bronchiolitis is not recommended as the findings are non-specific like hyperinflation and areas of atelectasis. Also, chest X-ray findings in infants with bronchiolitis are not associated with disease severity and do not guide the management (5).

Lung ultrasound (LUS) is considered to be valuable imaging modality as it is applicable, portable, easy to repeat and does not use ionizing radiations that are of special importance for infants who are more vulnerable to risk of cancer from exposure to radiation than other age groups (6). So, we search for other imaging modalities that do not use ionizing radiations to evaluate young individuals and minimize the risk of cancer (7).

The aim of this study was to assess the role of lung ultrasound in evaluation of infants with bronchiolitis.

2. Patients and methods

2.1. Patients

This study included 25 infants suspected clinically to have bronchiolitis according to the British Thoracic Society guidelines. The study was done during the period from January 2015 to January 2016, after approval of the local ethical committee. An informed written consent from each child's care given before enrollment into the study was taken.

Inclusion criteria were clinical signs and symptoms suggesting bronchiolitis; age > 1 month and < 24 month-old.

Exclusion criteria were any infant with congenital lung disease or known asthmatic infant.

The diagnostic gold standard was made by experienced pediatrician on the basis of clinical presentation and clinical course following British Thoracic Guidelines recommendations, and the pediatricians were blinded to LUS data. All patients underwent CXR on the day of the admission and were reviewed and reported by a radiologist who was informed about the clinical indication and was blinded to LUS findings. Also, the radiologist was informed about the clinical indication but was blinded to radiographic findings.

Clinical grading of the severity of bronchiolitis was based on guidelines suggested by Pediatric Society New Zealand and Scotland (8) and divided into mild, moderate or severe forms.

2.2. Methods

2.2.1. Chest X-ray examination

It was done by experienced X-ray technician under supervision of the radiologist and antero-posterior view was taken where the infant lies supine and sometimes the infant handled erect. Over couch tube and factors are adjusted using digital X-ray

Table 1 Clinical features of bronchiolitis patients (n = 25).

Clinical data	Number of infants
Shortness of breath (SOB)	25 (100%)
Fever	24 (96%)
Cough	25 (100%)
Cyanosis	1 (4%)
Expectoration	19 (76%)
Hemoptysis	0 (0%)
GIT symptoms	3 (12%)
Cardiac symptoms	0 (0%)
Similar attack	3 (12%)
Medical disease (DM malnutrition)	5 (20%)

Table 2 Clinical examination of bronchiolitis group (n = 25).

Clinical examination	Number of infants
Pallor	14 (56%)
Cyanosis	0 (0%)
Jaundice	1 (4%)
Wheezes	14 (56%)
Crepitations	19 (76%)
Grunting	1 (4%)

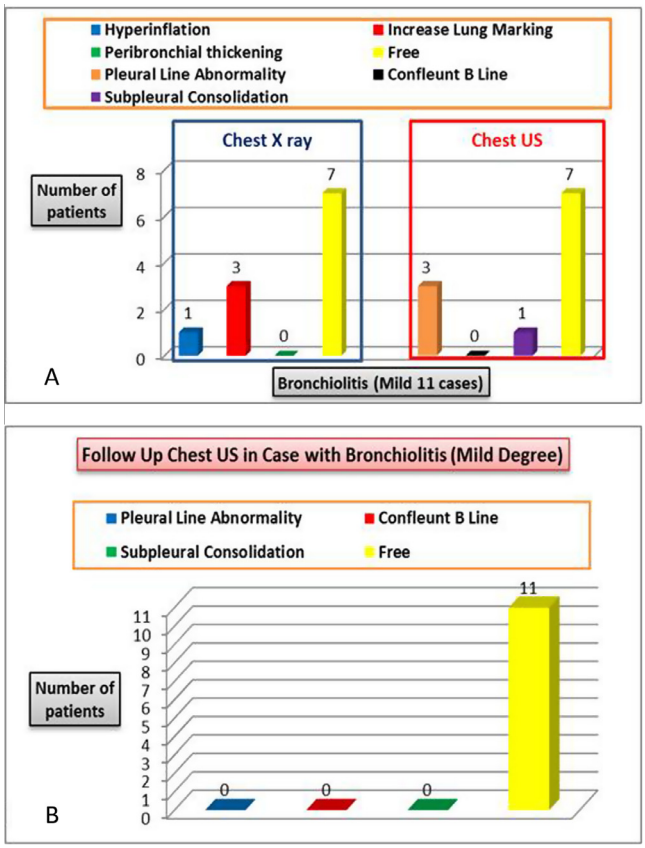

Fig. 1 A – On chest X-ray, 7 patients are normal, 3 patients showed increased lung markings and 1 patient with hyperinflation. On lung ultrasound, 7 patients are normal, 3 patients showed pleural line abnormalities and 1 patient with subpleural consolidation. B – Follow-up lung ultrasound in the same patients on A after 7–10 days treatment, revealed normal findings in all patients. (Mild degree of bronchiolitis.)

high technology machine (Philips 1000 mAs, Medical Systems, Germany). Then we evaluate the images for increased bronchovascular markings, hyperinflation or peribronchial thickenings or consolidation patches.

2.2.2. Lung ultrasound examination

It was done by one experienced radiologist using ultrasound machine (Logiq P5, GE Medical Systems, Korea) with 7.5–12 MHz-linear array transducer as follows: From anterior chest wall, the infant lies supine and the scan was done transversely from 2nd to 5th intercostal spaces and then longitudinally on the para-sternal, mid-clavicular, anterior and mid-axillary lines. From the posterior chest wall, the infant lies prone; the scan was done transversely below the scapular spine and longitudinally along the para-vertebral, scapular and posterior axillary lines.

In all patients first LUS examination was performed on the day of admission within 24 h of CXR examination, defined as day 1, then follow-up everyday for more than 10 days. The follow-up by lung ultrasound was stopped when the lung appeared normal.

Lung ultrasound findings of bronchiolitis included the following according to Caiulo et al. (9);

- Detection of area of tissue like or hypoechoic area with ill-defined margins at the subpleural region is considered to be subpleural area of consolidation (in 3 infants).
- Presence of longitudinal white lines on the lung named compact B-lines (in 6 infants).
- Irregularities in the pleural line are named pleural line abnormalities (in 8 infants).
- Multiple focal B-lines are also seen.
- The presence of normal lung sliding with or without A-lines is termed normal pattern (in 11 infants).

2.2.3. Statistical methodology

Statistical analysis was performed using the Statistical Package for Social Science (SPSS Inc., Chicago) version 21 for Microsoft Windows. Graphics were done by Excel. Data were described in terms of mean ± SEM (standard error of the mean) for continuous variables and frequencies using the independent Student's t-test.

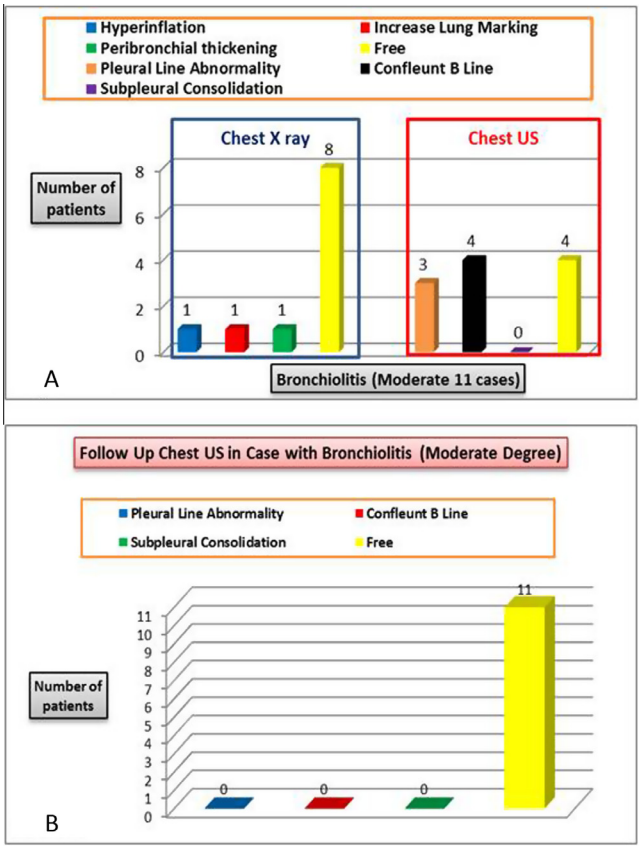

Fig. 2 A – On chest X-ray, 8 patients are normal, 1 patient showed hyperinflation, 1 patient with increased lung markings and 1 patient had peribronchial thickenings. On lung ultrasound, 4 patients are normal, 4 patients showed confluent B lines and 3 patients had pleural line abnormalities. B – Represents the follow-up lung ultrasound findings in the same cases on A after 7–12 days treatment with normal findings in all patients. (Moderate degree of bronchiolitis.)

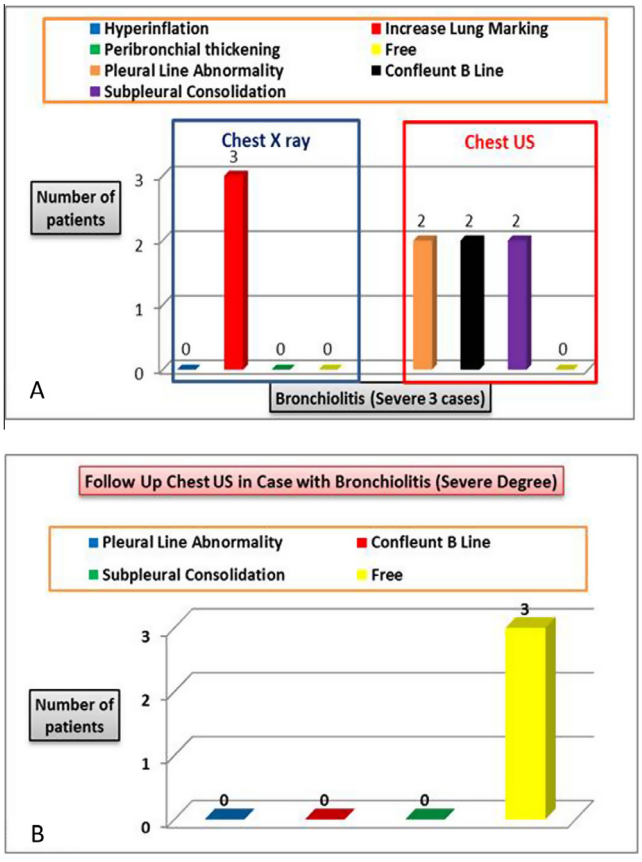

Fig. 3 A – On chest X-ray, 3 patients had increased lung markings. On lung ultrasound, the pleural line abnormalities noted in 2 patients, confluent B lines seen in 2 patients and subpleural consolidation detected on 2 patients with overlapping of the findings as some patients have more than one finding. B – Represents the follow-up lung ultrasound findings in the same cases on A after 10–15 days of treatment with normal findings in all patients. (Severe degree of bronchiolitis.)

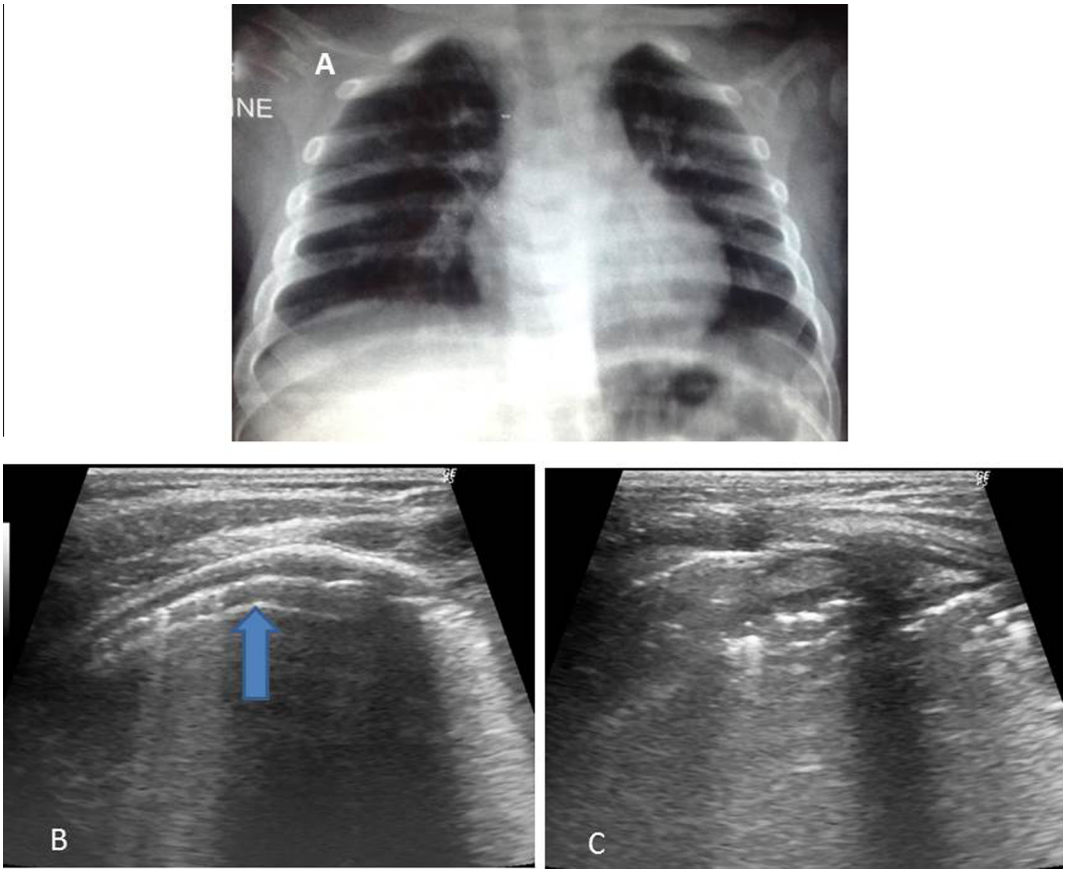

Fig. 4 A – Chest X-ray of 3 months-old infant with clinical suspicion of mild bronchiolitis revealed normal X-ray findings. B and C – Lung ultrasound of the same patient showed clearly the pleural line irregularities on Rt. lung (arrow on B). (Patient with normal chest X-ray and abnormal lung ultrasound.)

3. Results

This study included 25 infants, their ages ranged from 2 to 18 months (mean ± SD was 6.94 ± 4.48), 18 patients were female (72%) and 7 patients were male (28%). All cases presented by acute onset and their clinical symptoms are represented in Table 1.

General condition in our patients was normal in 11 patients (44%), irritable in 13 patients (52%) while 1 patient was lethargic (4%).

Local chest examination showed that respiratory rate ranged from 40 to 67 per minute with mean ± SD [52.4 ± 5.52], heart rate ranging from 40 to 67 b/m with mean ± SD 52.4 ± 5.52. Temperature of our patients ranged from 37 to 39.5 with mean ± SD 37.49 ± 0.53. Chest indrawing was mild in 8 patients [34%], moderate in 9 patients [36%], and severe in 2 patients [8%]. Air entry was diminished in 18 patients [72%], 14 patients [56%] had wheezy chest, 19 patients [76%] had crepitations, 1 patient [4%] had grunting, and harsh vesicular breath was found in 25 patients [100%]. Remaining clinical examination is shown in Table 2.

Respiratory support in the form of nasal cannula is in 21 patients [84%] and oxygen mask in 4 patients [16%], no one needed mechanical ventilation.

Classification of bronchiolitis according to the severity of disease into, mild degree noted in 11 patients (44%), moderate in 11 patients (44%) and severe in 3 patients (12%) was achieved.

3.1. Chest X-ray findings were the followings

Lung plethora with increased lung markings in 6 infants [24%]. Hyperinflation was present in 3 infants [12%]. Peribronchial thickening was present in one infant [4%] and normal chest X-ray found in 15 infants [60%].

- In mild bronchiolitis, chest X-ray showed pulmonary plethora [increase lung markings] in 2 patients, hyperinflation in 2 patients, peribronchial thickening in 1 patient and normal chest X-ray in 7 patients.
- In moderate bronchiolitis, chest X-ray showed pulmonary plethora with increased lung markings in 1 patient, peribronchial thickening in 1 patient, hyperinflation in 1 patient and normal chest X-ray in 8 patients.
- In severe bronchiolitis, chest X-ray showed pulmonary plethora in 3 patients with increased lung markings.

3.2. LUS in infants with bronchiolitis (n = 25) showed the followings:

Pleural line abnormalities (thick, irregular) were seen in 8 patients [32%], confluent compact B lines in 6 patients [24%], and subpleural lung consolidations in 3 patients

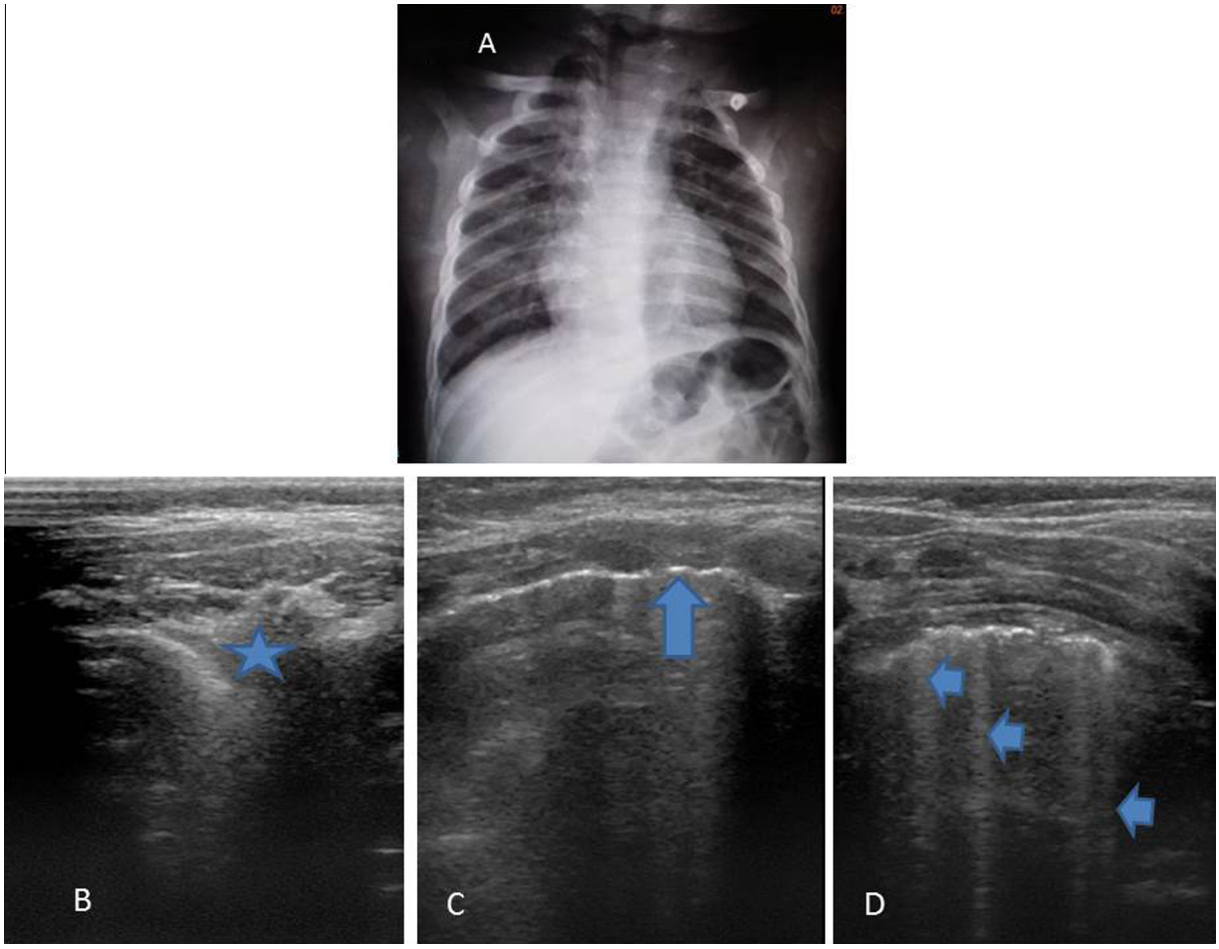

Fig. 5 A – Chest X-ray of 5 months-old infant with moderate bronchiolitis revealed increased bronchovascular markings and hyperinflation of both lungs. B – Lung ultrasound showed evidence of small tissue echogenic area sub-pleural in location mostly representing early consolidating area (star). C – It shows extensive pleural line irregularity clearly detected (arrow). D – Here, the horizontal arrows refer to the hyperechoic shadow of compact B lines on Rt. lung.

[12%]. No pleural effusion or any complications detected as it was mostly found with severe cases whose number was small. In 11 patients [44%] the lungs appeared normal with only small isolated B-lines and considered to be normal finding. In 1 patient [12%] we found three findings [pleural line abnormalities, compact B lines and subpleural consolidations] associated with severe case of bronchiolitis. In 4 patients [16%], the LUS findings were positive while the CXR findings were negative and the clinical course of the disease was consistent with bronchiolitis.

- In mild bronchiolitis, lung ultrasound showed normal ultrasound findings in 7 patients, pleural line abnormalities in 3 patients and confluent B lines in 1 patient.
- In moderate bronchiolitis, lung ultrasound showed normal findings in 4 patients, confluent B lines in 4 patients and pleural line abnormalities in 3 patients.
- In severe bronchiolitis, lung ultrasound showed pleural line abnormalities in 2 patients, confluent B lines in 2 patients and subpleural consolidations in 2 patients.

The follow-up of our patients everyday after initial ultrasound for more than 10 days was stopped when the lungs appeared normal. The decrease in size or disappearance of the subpleural hypoechoic areas was observed and this always correlated with the clinical improvement. Also, in all cases the disappearance of compact B-lines or changes to other patterns such as multiple isolated B-lines was considered sign of lung re-aeration. In all infants, the ultrasound signs of improvement were found to be correlated with the clinical condition. The pleural line abnormalities that were seen in 8 infants [24%], all disappear on the follow-up ultrasound and in all cases the clinical improvement was associated with disappearance of LUS findings (see Figs. 1–7).

4. Discussion

Bronchiolitis, is the most common reason for hospitalization of infants in many countries, occurring in epidemics during winter months (10). Also, it is the most common medical reason for admission of infants to intensive care units (ICU) (11).

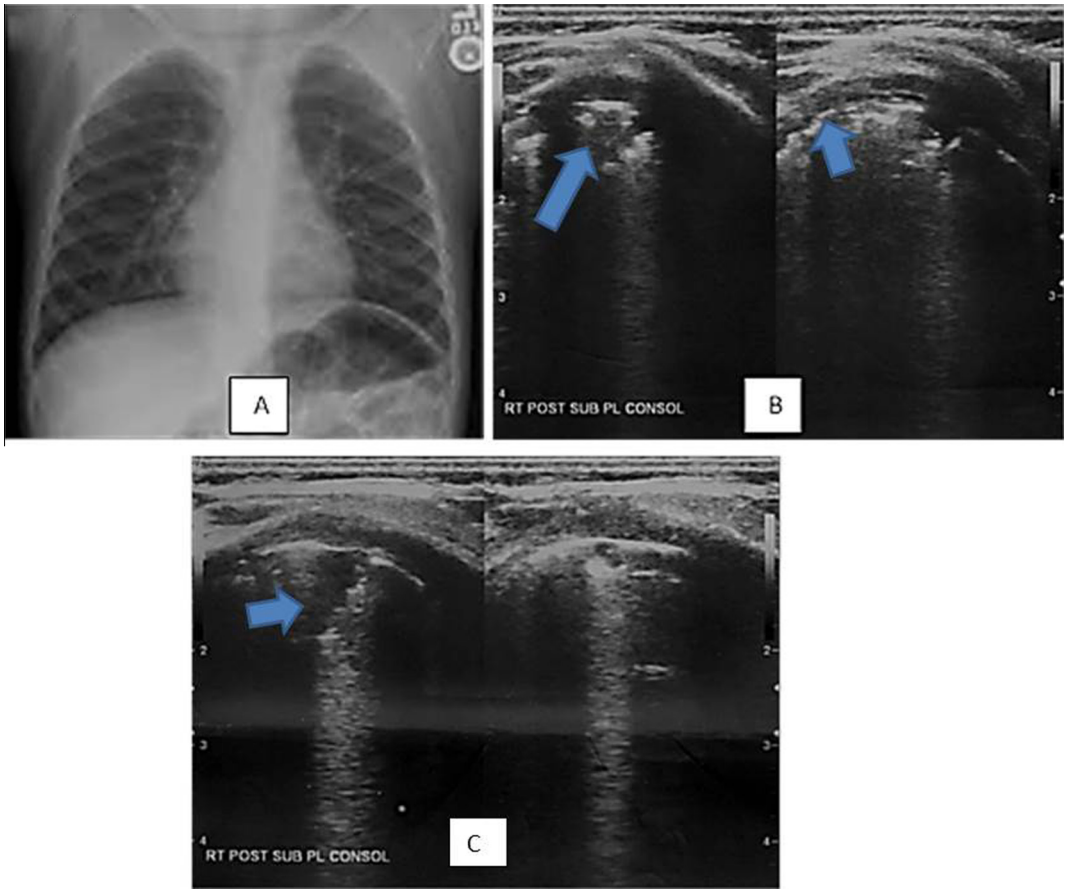

Fig. 6 A – Chest X-ray of 3 months-old infant with severe bronchiolitis revealed increased lung markings. B – Lung ultrasound of the same patient revealed posterior sub-pleural area of consolidation on the right lung (long arrow) with pleural line thickening and irregularity (short arrow). C – Showed posterior sub-pleural consolidation of the right lung (arrow) with isolated B-line.

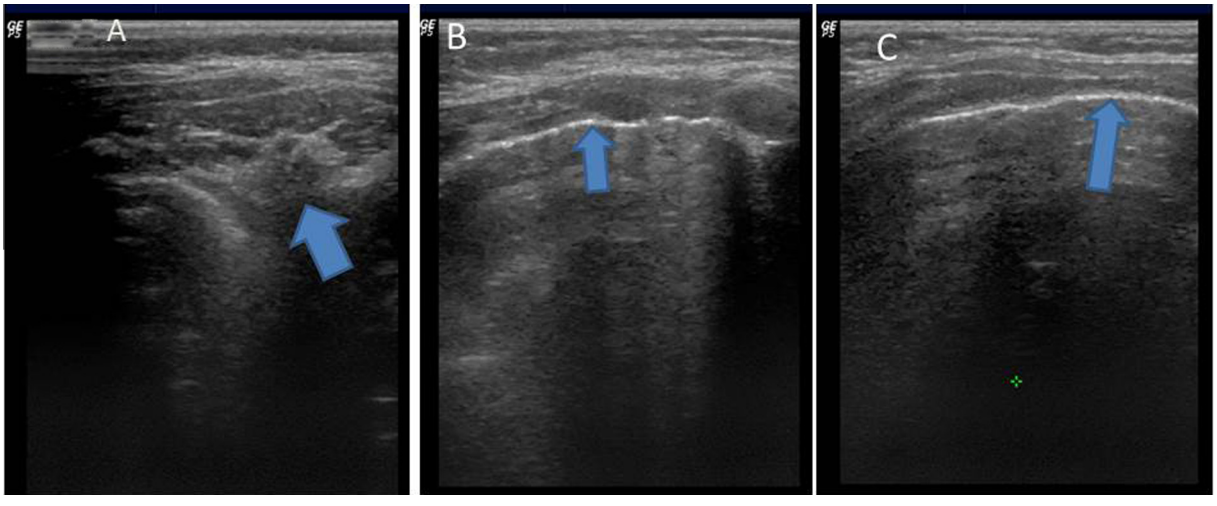

Fig. 7 Representing the lung ultrasound of 9 months-old infant with severe bronchiolitis and the follow-up findings: On A – There is triangular shaped hypoechoic area on the Rt. lung with findings corresponding to the subpleural area of consolidation (arrow). B – On follow-up of this infant after 8 days, resolution of the subpleural consolidation is noted but still, there is residual pleural line irregularities (arrow). C – On follow-up after 12 days, it revealed near complete resolution of the above described findings and even the pleural line appeared nearly normal.

Some infants, particularly those with risk factors, will have a severe course of bronchiolitis. A substantial proportion of children will experience at least one episode with bronchiolitis, and as much as 2–3% of all children will be hospitalized with bronchiolitis during their first year of life (12). The diagnosis of bronchiolitis was mainly based on the patient's medical history and physical examination and this was also approved by Caiulo et al. (13).

In this research we found that from 25 infants diagnosed clinically as having bronchiolitis, 14 patients (56%) had positive LUS findings in the form of pleural line abnormalities, confluent B lines and/or subpleural consolidations. The commonest of which was pleural line irregularity, positive in 8 patients (32%), then confluent B lines, positive in 6 patients (24%) and lastly subpleural consolidations that were positive in 3 patients (12%). A study done by Basile et al. (14), resulted in the fact that 8% infants were normal at chest ultrasound; 40% have interstitial infiltrations without atelectasis, 48% with atelectasis, 8% have minimal pleural effusion and none pneumothorax. Clinically, the interstitial infiltrations (means of peribronchial or alveolar septal fibrosis) were present in 82% (18% with atelectasis) of cases with mild bronchiolitis, in 90% (70% with atelectasis) with moderate bronchiolitis and in the totality of severe bronchiolitis (75% with atelectasis).

In this study, CXR was positive in 10 patients only (40%) in the form of hyperinflation, increased lung markings and peribronchial thickenings. Increased bronchovascular markings of the lung were the commonest finding (positive in 6 patients (24%)), followed by hyperinflation (positive in 3 patients (12%)) and lastly peribronchial thickenings (positive in only one patient (4%)). A study done by Schuhs et al. (15) on 265 infants with simple bronchiolitis, routine chest X-ray identified findings consistent with bronchiolitis in only 2 cases and after reviewing the abnormal findings in the radiographs; the clinicians treat patients by antibiotics, although the findings did not support that management.

In this research, 4 patients (24%) were with positive LUS and negative CXR, and the clinical course of the disease was consistent with bronchiolitis. These results are in agreement with 2 studies (13,14), who found that the ultrasound findings were correlated with the clinical suspicion considering the disease course and outcome. Also, Caiulo et al. (9) postulated that lung ultrasound is now being reported as a better and easy choice for the diagnosis of bronchiolitis. On the contrary (16) it was doubtful about the real meaning of small subpleural lung consolidations and pleural line abnormalities as ultrasound findings.

In addition, Volpicelli et al. (17) found that there were some limitations to LUS, as it can miss consolidations that do not reach the pleura.

The use of lung ultrasound can detect early abnormalities that could not be seen by CXR, with many advantages as it can reduce the time needed to reach the final medical report without radiation exposure. In our study 4 patients showed ultrasound findings were negative on CXR. On the other hand, there was a good correlation between the clinical condition of the infants and the ultrasound findings, as all patients suspected by LUS as having bronchiolitis were diagnosed clinically and proved on the follow-up. Caiulo et al. (9) reported on their study as 9 of 52 patients had negative CXR findings that were positive on lung ultrasound examination showing many abnormalities including pleural line irregularities and thickenings as well as compact B-lines. Also, Soldati et al. (18) stated that the use of lung ultrasound can dramatically reduce the need for chest X-ray.

5. Conclusion

In bronchiolitis, lung ultrasound with no radiation exposure can offer a non-invasive, rapid, reproducible and relatively in-expensive diagnostic tool. It can reduce the need for chest X-ray and should be recommended in infants with clinical signs and symptoms of suspected bronchiolitis.

Conflict of interest

All authors have materially participated in the research preparation and agreed for the submission.

We have no conflict of interest to declare.

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