Original Article

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Radiology Section

# Ultrasound Imaging in the Early Detection of Transient Tachypnoea of the Newborn: A Cross-sectional Study

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## ABSTRACT

**Introduction:** The most common cause of perinatal dyspnoea, frequently diagnosed on chest radiographs, is Transient Tachypnoea of Newborn (TTN). Lung Ultrasound (LUS) is recognised as a promising tool that has been proven in recent studies and tends to have better diagnostic capability.

**Aim:** To describe the sonographic features of TTN and assess their clinical importance in early diagnosis.

**Materials and Methods:** This cross-sectional hospital-based study was conducted at Department of Radiology, AJ Institute of Medical Sciences and Research Centre, Mangaluru, Karnataka, India, from November 2020 to May 2022. Newborns with tachypnoea admitted to the Neonatal Intensive Care Unit (NICU) were enrolled in this study. In a stable state, the infants were placed in supine, lateral, and prone positions for the ultrasound scan. LUS was performed on a total of 94 infants. Along with ultrasound, a chest radiograph was also taken. Follow-up LUS was performed on days 2, 3, and on the day of discharge from the NICU. The sonographic findings of TTN were evaluated using Pearson's Chi-squared test. A p-value of <0.05 was considered statistically significant.

**Results:** Based on clinical manifestations, chest radiograph, and LUS, 60 newborns were diagnosed with TTN, and 34 had Respiratory Distress Syndrome (RDS). Out of the 60 newborns, the gestational age ranged from 32 weeks to 40 weeks, with a mean of 38 weeks+four days. Double Lung Point (DLP) was noted in 41 newborns with TTN, which showed a sensitivity and specificity of 68% and 100%, respectively, with a positive predictive value of 100%.

**Conclusion:** The LUS could be widely used in the NICU as the first line of screening for the primary diagnosis of TTN and for early initiation of treatment accordingly.

**Keywords:** Chest radiographs, Double lung point, Lung ultrasound, Respiratory distress syndrome

## INTRODUCTION

The most common cause of perinatal dyspnoea is TTN. It is a benign self-limiting condition seen in term and late preterm infants, due to delayed clearance of lung fluid [1]. TTN can last for 4 to 72 hours after birth. Antenatally, the lung fluid in the distal airway plays a crucial role in foetal lung growth and development by maintaining the lung fields in a distended state. Larger fluid volumes provide a greater stimulus for lung growth during gestation [2]. However, at birth, the interstitial lung fluid should get cleared for entry of air into the lung and exchange of gases across alveoli [3]. At birth, the lung undergoes fluid clearance into the surrounding parenchymal tissue within minutes and from there to lymphatics and blood vessels within four to six hours of birth [4]. As a result, there is an effect on breathing, and the infants present with distress due to volume overload in the lungs. Hence, it is thought to result from a failure to adequately clear airway fluid after birth and is characterised by tachypnoea with signs of mild respiratory distress, including retractions, reduced oxygen saturation, and cyanosis [5].

The TTN is seen more commonly in infants born near term by elective Caesarean Section (CS) [6]. TTN has always been a diagnosis of exclusion, with chest radiographs being the gold standard in aiding diagnosis. However, a few essential diagnoses may be missed in which respiratory distress may resolve or decrease within the time frame of four to 72 hours. Hence, a reliable screening tool is necessary for the effective management of respiratory distress in newborns, thus reducing the stay of newborns in the NICU and lowering morbidities.

It is important to evaluate the disease progression and monitor the disease process by means of ultrasonography, as it provides a non invasive and less time-consuming approach, with minimal or no side-effects. Very few studies have been conducted in India pertaining to the use of LUS in NICU care [5-7]. LUS has proven useful in the early diagnosis of TTN. The main objective of the present study was to establish the clinical relevance of lung sonography in TTN. The sonographic findings of TTN were compared with conventional radiographic findings for better accuracy.

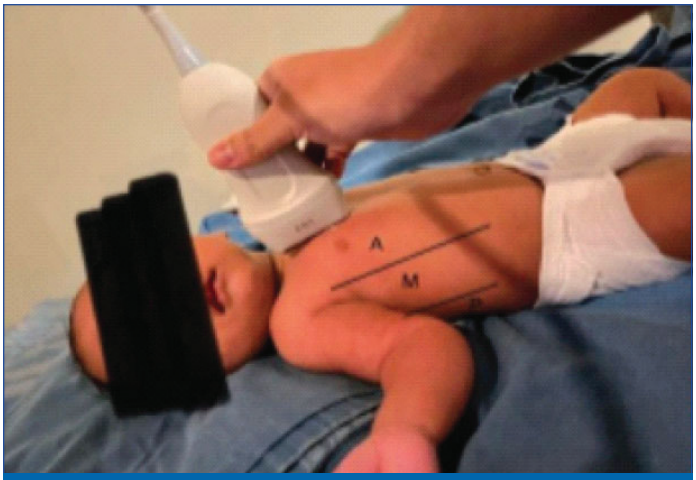
## MATERIALS AND METHODS

This cross-sectional hospital-based study was conducted from November 2020 to May 2022 at Department of Radiology, AJ Institute of Medical Sciences and Research Centre, Mangaluru, Karnataka, India. The study was approved by the Institutional Research Ethics Committee (AJEC/REV/142/2020).

**Inclusion and Exclusion criteria:** All newborns with tachypnoea and respiratory distress within four hours of birth were included in the study. Newborns presenting with symptoms after four hours of life and those with meconium aspiration were excluded from the study.

### Study Procedure

The cases were provisionally diagnosed as TTN or RDS based on antenatal history, mode of delivery, and perinatal events. LUS was performed for 94 newborns in a stable and quiet state. The infants were placed in supine, lateral, and prone positions. Along the posterior and anterior axillary lines, each lung was divided into three sections: the anterior, lateral, and posterior regions. These regions were further separated into upper and lower segments at the level of the nipple anteriorly, axillary fold laterally, and mid-scapula posteriorly [Table/Fig-1]. A 7.5 Hz or higher frequency linear probe was preferred. The probe was held in a longitudinal or craniocaudal orientation with a marker facing cephalad. The probe was kept perpendicular to the ribs. Each region of both lung fields was carefully scanned to observe the relevant findings.

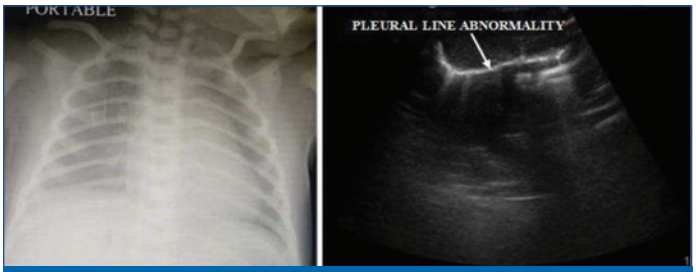



**[Table/Fig-1]:** Lung zones divided into three regions– anterior, lateral and posterior regions by anterior and posterior axillary lines. Transducer kept in craniocaudal orientation and perpendicular to the body.

## Definitions

**Pleural line:** a uniform echogenic line under the superficial layers of the thorax that moves rhythmically with respiration. The movement of the pleura is described as the *'lung sliding sign'*.

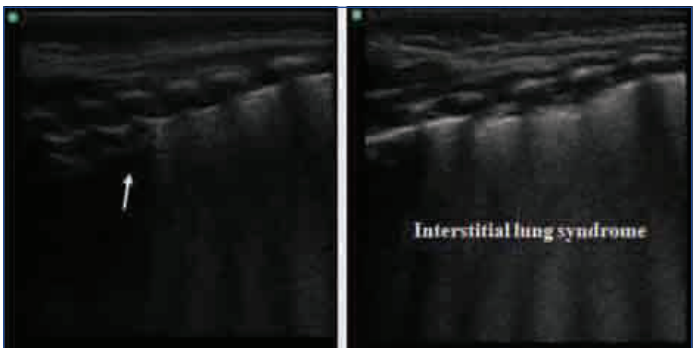
**A-line:** a sequence of echogenic, horizontal, parallel lines that are equidistant from one another below the pleural line [Table/Fig-2].




**[Table/Fig-2]:** LUS manifestation of TTN: Pleural line thickness with disappearance of A-lines. The infant was born via Lower Segment Caesarean Section (LSCS) at gestational age of 35 weeks+3 days, had respiratory distress at birth. At two hours of life, Chest X-ray (CXR) was insignificant, however, LUS showed pleural line abnormality and disappearance of A-lines (arrow). (Images from left to right)

**B-line:** also known as ultrasound lung comets, hyperechoic narrow-based artifacts that spread similar to laser rays from the pleural line to the edge of the screen.

**Interstitial syndrome:** the presence of more than 3 B-lines in every examined area [Table/Fig-3].

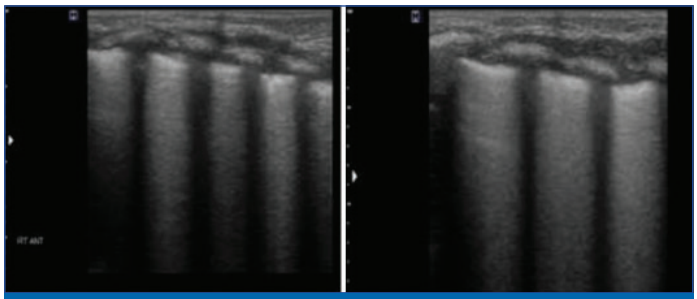



**[Table/Fig-3]:** LUS manifestation of 33-week-old female baby born via normal vaginal delivery. Noted to have tachypnoea at birth. The right lung showed DLP (arrow), however, interstitial lung syndrome was noted in left lung. (Images from left to right)

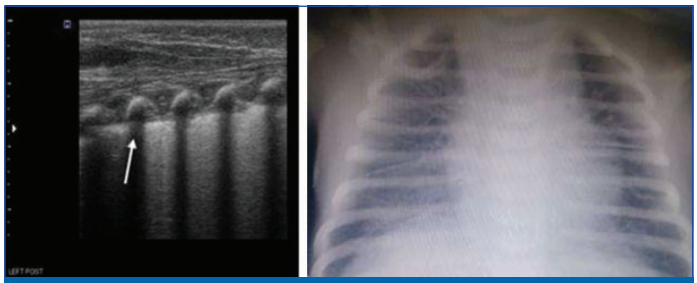
**White lung:** the presence of compact B-lines in six areas without horizontal reverberation [Table/Fig-4].

**Double Lung Point (DLP):** A longitudinal scan depicts a clear differentiation between the upper and lower lung fields due to the difference in the nature of pathological changes in different areas of the lung. This exact cut-off point between the upper and lower lung fields is termed as DLP [Table/Fig-5] [8,9].

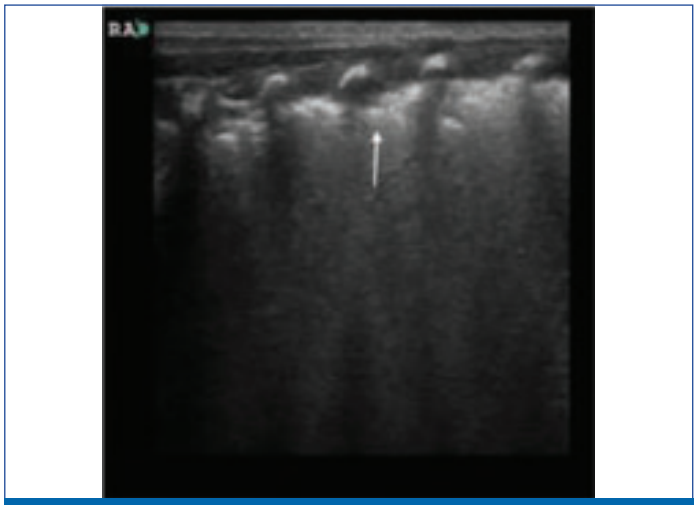
**Lung consolidation:** areas of hepatisation with the presence of air bronchograms [Table/Fig-6].



**[Table/Fig-4]:** LUS manifestation of RDS: B/L white out lungs. A female 29 weeks +2 days was born via LSCS, had respiratory distress. At one hour of life, LUS was done which showed complete white out: compact b-lines in >4 regions of both lungs along with pleural line thickness and interstitial lung syndrome. (Images from left to right)



**[Table/Fig-5]:** LUS and X-ray manifestation of TTN. These are the figures of 40 weeks +2 days male baby born via LSCS and noted to have respiratory distress at birth. CXR and LUS done at three hours of life. LUS showed DLP in posterior regions (arrow). CXR: sunburst appearance with pleural fissure thickening noted bilaterally. (Images from left to right)



**[Table/Fig-6]:** LUS manifestation of Pneumonia. A 34-week female baby born via NVD had respiratory distress. LUS was suggestive of lung consolidation (arrow).

According to the Lichtenstein classification, B-lines are vertically oriented comet tail artifacts arising from the pleural line, which are absent in the normal lung. They arise from the pleural line, which erases A-lines, and move with lung sliding. These artifacts are in correlation with the pathological findings due to the presence of fluid-rich subpleural interlobular septae, which are encircled by air. This is identified as alveolar interstitial syndrome. The foetal lung is very rich in fluids, and therefore, B-lines can also be seen in healthy-term newborns born both vaginally and by CS, more frequently seen in the latter. They are neither compact nor numerous. They are more commonly seen on the right side without any localisation and can disappear completely within 24 to 36 hours [1].

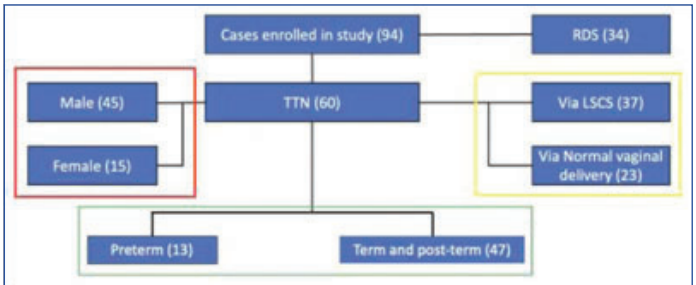
After performing LUS, a chest radiograph was performed for these infants to confirm the findings. Follow-up LUS was performed on days 2, 3, and on the day of discharge from the NICU. LUS findings were compared with clinical and radiographic findings, after which the sensitivity and specificity of the findings in the diagnosis of TTN were determined.

## STATISTICAL ANALYSIS

The statistical analysis was performed using Statistical Package for Social Sciences (SPSS) software, version 22.0. The clinical features and lung sonographic findings were represented as the mean and standard deviation. The sonographic findings of TTN were evaluated using Pearson's Chi-squared test. A p-value of <0.05 was considered statistically significant.

## RESULTS

A total of 94 patients who were admitted to the NICU with symptoms of respiratory distress and met the inclusion criteria were enrolled in the present study. These 94 patients presented with respiratory distress within four hours after birth. Based on the clinical manifestations, X-rays, and LUS, 60 newborns were diagnosed with TTN and 34 newborns with RDS. Among the cases of TTN, the gestational age ranged from 32 weeks to 40 weeks, with a mean of 38 weeks + four days. Of the 60 cases, 45 newborns (75%) were male and 15 newborns (25%) were female. Among the TTN cases, 50 (83%) were appropriate for gestational age foetuses, 7 (12%) were small for gestational age, and 3 (5%) were large for gestational age foetuses. A total of 47 TTN cases were seen in term and post-term neonates, and 13 cases were seen in preterm neonates. The incidence of TTN was higher in newborns delivered via LSCS (37 neonates, 61.6%) compared to newborns born via vaginal delivery (23 neonates, 38.3%). Among the 60 newborns, 24 cases (40%) had a normal chest X-ray, 19 cases (32%) had features of RDS, and 17 cases (28%) had features of TTN [Table/Fig-7].




**[Table/Fig-7]:** Shows the case distribution based on gender, mode and time of delivery.

The LUS findings included DLP, consolidation with air bronchograms, pleural line abnormalities, interstitial lung syndrome, white out lung (compact B-lines), and A-line disappearance [Table/Fig-8]. DLP was noticed in 41 out of 60 cases of TTN (68.3%), and 19 cases (31.6%) had no DLP. All cases of TTN showed pleural line abnormalities, interstitial syndrome, and A-line disappearance. [Table/Fig-9] demonstrates the sensitivity, specificity, and positive predictive value of LUS findings in TTN.

| LUS findings | TTN | RDS | p-value |
|---|---|---|---|
| Double Lung Point (DLP) | 41 | 0 | <0.001 |
| Consolidation | 0 | 30 | 0.002 |
| Pleural line abnormalities | 60 | 34 | 0.002 |
| Interstitial syndrome | 60 | 34 | 0.002 |
| A-line disappearance | 60 | 34 | 0.002 |

**[Table/Fig-8]:** LUS findings in total cases (94). Chi-square test was used.

| LUS finding in TTN | Sensitivity | Specificity | PPV | p-value |
|---|---|---|---|---|
| DLP | 68% | 100% | 100% | <0.001 |
| Pleural line abnormalities | 100% | 100% | 100% | 0.002 |
| Interstitial syndrome | 100% | 100% | 100% | 0.002 |
| A-line disappearance | 100% | 100% | 100% | 0.002 |

**[Table/Fig-9]:** Accuracy of LUS findings in TTN. Pearson's chi-square test was used.

Repeat lung sonography was performed on Day 2, Day 3, and on the day of discharge to evaluate the disease process. [Table/Fig-10] shows the follow-up LUS findings of the cases on Day 2, 3, and at discharge. Fischer's-exact test was done for statistical analysis. 96.6% of TTN cases had normal LUS by day 2 and day 3. 38.2% of cases of RDS were noted to have normal LUS on day 2, 88.7% of cases had normal LUS by day 3, and by discharge, all 34 cases had normal LUS. A p-value of 1E-06 was noted.

| Cases (n) | Day 2 | | Day 3 | | Discharge | | p-value |
|---|---|---|---|---|---|---|---|
| | Normal n (%) | Abnormal n (%) | Normal n (%) | Abnormal n (%) | Normal n (%) | Abnormal n (%) | |
| TTN (60) | 56 (93.3) | 4 (6.7) | 60 (100) | 0 (0) | 60 (100) | 0 (0) | 1.8 E-05 |
| RDS (34) | 13 (38.2) | 21 (61.8) | 30 (88.7) | 4 (11.3) | 34 (100) | 0 (0) | 1 E-06 |

**[Table/Fig-10]:** Follow-up LUS of cases.

The findings of TTN on chest radiographs included lung hyperinflation with prominent perihilar interstitial markings. The grading of RDS on chest radiographs ranged from homogeneous ground-glass shadowing to complete white out lung fields [Table/Fig-11].

| Conditions | X-ray findings |
|---|---|
| TTN (60) | Lung hyperinflation/over aeration<br>Prominent perihilar interstitial marking (sunburst appearance) |
| Pneumonia | Localised or diffuse alveolar densities/opacities |
| RDS (34) | Grade-1: Fine homogenous ground glass shadowing (18) |
| | Grade-2: Widespread air bronchogram (5) |
| | Grade-3: Confluent alveolar shadowing (3) |
| | Grade-4: Complete white lung fields (8) |

**[Table/Fig-11]:** X-ray findings.

## DISCUSSION

The TTNs are a benign, self-limiting condition seen in term and late preterm infants due to delayed or deficient clearance of lung fluid [1]. These symptoms usually persist for about 12 to 24 hours after birth in mild forms, however, they could last up to five days [5,10]. TTN constitutes about 40% of NICU admissions and is documented in 1% of preterm deliveries and 0.3 to 0.6% of term deliveries. Early symptoms of TTN are often indistinguishable from other neonatal conditions such as RDS, pneumonia, Meconium Aspiration Syndrome (MAS), and persistent pulmonary hypertension, presenting a diagnostic and therapeutic challenge in the newborn nursery [10]. Although TTN rarely causes neonatal death, it is important to accurately differentiate it from other causes of dyspnoea for appropriate management of infants with respiratory distress [11].

In the present study, 6 (10%) cases were preterm neonates, 51 (85%) were term neonates, and 3 (5%) were post-term neonates. A study by Gupta V et al., showed a mean gestational age of 32.9±2.5 weeks [12]. The incidence of TTN was higher in newborns delivered via LSCS (37 neonates, 61.6%) compared to newborns born via vaginal delivery (23 neonates, 38.3%). This is consistent with the study conducted by De Martino L et al., where the majority of newborns were born via CS [13].

Chest X-ray remains the gold standard for diagnosis and shows fluid in the fissures and prominent perihilar streaking due to engorgement of the lymphatic system by retained lung fluid. These abnormalities resolve within 72 hours [14]. In the present study, the findings of TTN on X-ray included lung hyperinflation with prominent perihilar interstitial markings. The most commonly reported findings of RDS on X-rays were homogenous ground-glass shadowing (Grade-1 RDS) or white-out lung fields (Grade-4 RDS). In a hospital-based cross-sectional study conducted by Zarei E and Alizadeh V, the most prevalent findings were haziness and consolidation [15]. The X-ray findings in this study showed a sensitivity and positive predictive value of 56.67% and 100% respectively, whereas ultrasound findings showed 93.22% sensitivity and 98.21% positive predictive value.

In the present study, the LUS findings included DLP, consolidation with air bronchograms, pleural line abnormalities, interstitial lung syndrome, white out lung, and A-line disappearance. In a study conducted by Pasic IS et al., the ultrasonography findings included irregularities of pleural lines, presence of confluence B-lines, and subpleural consolidations [16]. Raimondi F et al., used three simple ultrasound patterns-white lung, B-lines, and A-lines-to monitor fluid clearance in newborns, and the study concluded that lung ultrasonography has been a useful tool in predicting the need for respiratory support [17]. In the present study, findings of white-out lung and pleural line abnormalities were commonly found in RDS. Gupta V et al., reported that pleural line abnormality is one of the most common abnormalities in RDS, although it was also seen in TTN [12]. According to the literature, the sensitivity and specificity of pleural line abnormalities for the diagnosis of RDS are 100% and 45%, respectively [18]. El Masry HMA et al., depicted that the absence of A-lines and pleural line abnormalities were common LUS findings in TTN [19].

Early exposure of infants and children to radiation may lead to a higher risk of developing malignancies later in life. Due to the larger percentage of dividing cells, growing children are more radiosensitive. Hence, newer radiological modalities like ultrasound-based diagnoses are required in the present era of evidence-based medicine [20]. Bedside chest radiography may have its own limitations. Firstly, while acquiring the chest radiograph, the patient and thorax may move, which causes a decrease in spatial resolution of the radiological image. Secondly, the cassette is placed posterior to the thorax. Finally, the X-ray beam emerges anteriorly at a shorter distance than recommended and not quite interjectionally to the diaphragmatic cupola, therefore hampering the correct interpretation of the silhouette sign. These practical difficulties can lead to incorrect assessment of pleural effusion, interstitial syndrome, and lung consolidation.

### Limitation(s)

Lung ultrasonography is operator-dependent and can vary among radiologists. Additionally, performing an ultrasound examination may take longer than acquiring a chest radiograph. It is important to note that A-line and B-lines seen on LUS can also be visualised in other pulmonary conditions, which may necessitate further evaluation and comparison with other imaging modalities. Furthermore, it is important to consider that this study is a single-centre study, and the findings may not be generalisable to the entire population.

## CONCLUSION(S)

Lung ultrasonography is a reliable and non invasive investigation of choice that can help in the management of neonatal respiratory distress. It can be performed on multiple occasions and used for regular follow-ups. LUS can be used in addition to chest radiography to diagnose TTN and RDS. The main advantage of LUS is the decrease in radiation exposure to infants and its ability to provide better and more accurate results in the early diagnosis of TTN.

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