LUNG ULTRASONOGRAPHY DECREASES RADIATION EXPOSURE IN NEWBORNS WITH RESPIRATORY DISTRESS: A RETROSPECTIVE OBSERVATIONAL STUDY

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Abstract

Background:Chest X-ray(CXR) is commonly used as a first line imaging method to diagnose the reason of respiratory distress in NICUs.Lung ultrasound is a new diagnostic tool for lung imaging.Objectives:We aimed to determine the decrease in the number of CXRs on the first day of life in newborns with respiratory distress,with the use of lung ultrasonography.Methods:From January 2019 to June 2020,104 newborn infants hospitalized in the NICU with respiratory distress on the first day of life enrolled in this study(ClinicalTrials.govIdentifier NCT04722016).We used ultrasound as the first line technique for lung imaging.CXR was taken to determine endotracheal tube and umbilical catheter position or if considered necessary by the physician in charge of the infant.We calculated decreased number of CXR for every patient and evaluated the estimated decrease in radiation exposure.Results:104 neonates with median 36 weeks(25-40)gestational age and birth weight 2410gr(600-4100) enrolled in the study.Seventy(67,3%)of these babies were male.In the study group,24(23,1 %)patients were diagnosed with respiratory distress syndrome(RDS),49(47,1 %) patients with transient tachypnea of newborn(TTN),27(26 %) with pneumonia,4(3,8 %)with congenital heart diseases.Lung ultrasonography were performed 210 times for all infants,but CXRs were performed a total of only 107 times.CXR wasnot taken in 27 of the patients with a diagnosis of TTN,in 2 of the patients with a diagnosis of congenital pneumonia,and in one of the patients with congenital heart disease.The rate of patients who have never had a chest x-ray was 28,8%.Conclusions:We observed that usage of lung ultrasonography decreased the number of chest X-ray and radiation exposure in newborns with respiratory distress.

INTRODUCTION

Respiratory distress is one of the most common problems occurring in 5% term and 29% preterm babies requiring admission to the neonatal intensive care unit (NICU), leading to 20% of neonatal deaths.[1]

The most important cause of respiratory distress in premature newborns admitted to NICU is respiratory distress syndrome (RDS) due to surfactant deficiency. There may be many reasons causing respiratory distress in term babies, but the most important are transient tachypnea of the newborn, pneumonia, congenital heart disease, meconium aspiration syndrome, and air leak syndromes. Newborns admitted to NICU with respiratory distress are diagnosed with imaging methods, in addition to clinical examination and laboratory data. Chest X-ray (CXR) is commonly used as the first-line imaging method to diagnose the reason of respiratory distress in NICUs. Vergine et al.[2]confirmed that 59 patients suspected to have RDS through CXR had a sensitivity and specificity of 91% and 84%, respectively. However, chest radiography involves exposure to ionizing radiation. Therefore, newborns are at greater risk from the latent effects of CXR compared with other age groups because of their small size and affinity to radiosensitive tissues and organs.[3]

Lung ultrasound is a new diagnostic tool for lung imaging, and this method has been used more commonly in

NICUs. The first report on the use of lung ultrasonography (LUS) in adult medicine appeared in 1995, and since then, LUS has become widespread in pediatrics and neonatology.[4] LUS is a point-of-care, easy-to-learn, radiation-free, bedside, quick, and repeatable technique. It is an easy-to-apply imaging method for to use on the smallest patients and in the critical care setting. Lung diseases, such as pneumonia, transient tachypnea of the newborn, and RDS, can be diagnosed with lung ultrasound.[5] In our intensive care unit, LUS has been used as the first method in newborns with respiratory distress for the last five years. In this study, we aimed to determine the decrease in the number of CXRs in newborns with respiratory distress with the use of LUS.

METHODS

Study Design and Settings

This work is a retrospective observational study conducted in Hacettepe University Intensive Care Unit from January 2019 to June 2020. Neonates born term or preterm with respiratory distress enrolled in the study on the first day of life. LUS was performed intermittently by a neonatology fellow who was trained and certified on this subject. Chest radiography was taken to determine endotracheal tube and umbilical catheter position or if considered necessary by the physician in charge of the infant.

Clinical findings of neonates, number of LUS in the first 24 h, and the number of CXRs taken were obtained from the files and the hospital information system and were recorded.

This study aimed to determine how many CXRs, and thus the radiation dose exposed per total and body weight, had been reduced with the use of effective LUS on the first day of life for respiratory distress in NICU for a period of eighteen months.

The study was approved by our local ethical committee. The protocol was registered with ClinicalTrials.gov Identifier NCT04722016.

Inclusion Criteria

Term or preterm neonates with respiratory distress that started within the first 24 h after birth were included in the study. Respiratory distress is defined as follows: tachypnea (respiratory rate $>$ 60 breaths/min), intercostal/subcostal retractions, grunting, or FiO2 requirement $>$ 0.21.

Exclusion Criteria

Patients with major congenital malformations or chromosomal abnormalities, inherited metabolic diseases, congenital muscle disease, and hypoxic-ischemic encephalopathy were not enrolled.

LUS Procedure

LUS was conducted with a Philips CX50 (Philips, Eindhoven, the Netherlands) ultrasound machine using a high-frequency (13- 5 MHz) linear transducer probe (Acuson X300, Siemens, Erlangen, Germany). The infants were placed in a supine position in an incubator or under a radiant warmer to scan the upper anterior, lower anterior, and lateral chest areas.

Lung ultrasound diagnostic criteria for respiratory distress syndrome were bilateral sign of abnormalities of the pleural line, white lung image or dominant B lines and absence of spared area in all lung fields[2,14] (Figure 1). Lung ultrasound diagnostic criteria for transient tachypnea of the newborn were normal or blurry pleural line, and double lung point or numerous noncompact B-lines[2] (Figure 2). Pneumothorax was diagnosed in the absence sliding sign and presence of lung point[21]. Pneumonia was diagnosed in the presence of pleural line abnormalities, lung consolidation, hepatization of the subpleural lung tissues and disappearance of lung sliding[18] (Figure 3). Lung ultrasound score was used to predict the severity of respiratory illness.[15]

CXR Procedure

CXRs were obtained in the anterior-posterior view and were performed when required by neonatologists. CXRs which were evaluated by neonatologists based on definitions are indicated below. The radiographic technique, particularly supine projection, must be considered when interpreting neonatal CXRs. In the diagnosis of TTN, CXR shows slightly over-inflated lung fields with increased interstitial streaky shadowing extending to the peripheral pulmonary fields in association with a normal or mildly enlarged heart and occasionally small pleural effusions. In RDS, the CXR shows fine, homogeneous ground-glass shadowing, widespread air bronchograms, or complete white-out of the lung fields with obscuring of the cardiac border in the most severe cases. In pneumonia, the CXR may show patchy or confluent pulmonary infiltrates typical of infection or increased interstitial shadowing.[9]

Statistical Analysis

The mean ± standard deviation or median (minimum-maximum) were used according to the distribution of the demographic data. The two-ratio z-test was used to compare the rates, and the Kruskal-Wallis test was used to determine whether there was a difference in the numerical variables in the number of graphs (0-1-2-3). The Dunn-Bonferroni test, one of the multiple comparison tests, was used to determine which groups caused the difference. In the analysis, the type I error was taken as 0.05. Statistical analysis was conducted using the IBM SPSS V22 program.

RESULTS

A total of 104 newborn infants with respiratory distress from January 2019 to June 2020 enrolled in this study. The study group included 70 (67.3%) male and 34 (32.7%) female patients. The gestational ages of the patients were between 25 weeks and 40 weeks (median 36 weeks). The birth weights of the patients were between 600–4,310 g (median 2,410 g). Thirty-seven (36%) of the patients were born prematurely, and 67 (64%) were born on time. Table 1 shows the demographics and the mothers' disease.

Out of 104 infants, who had respiratory distress when they were admitted to NICU, 32 (30.8%) did not need respiratory support, tachypnea and oxygen need has declined within hours, 64 (61.5%) received noninvasive respiratory support, and 8 (7.7%) were put on invasive mechanical ventilation.

In the study group, 24 (23.1%) patients were diagnosed as RDS, 49 (47.1%) as TTN, 27 (26%) as pneumonia, and 4 (3.8%) as congenital heart diseases.

A total of 104 patients were evaluated with CXR 107 times. 57 of 107 films were taken for umbilical venous/ arterial catheter site confirmation.

A negative correlation was found in the number of radiographs taken, between birth weight and gestational weeks ($p < 0.001$ and $p < 0.001$, respectively).

A significant difference was found between the diagnosis of the patients and the number of CXRs ($p < 0.001$). The number of x rays taken per patient were statistically different according to diagnosis.

27 out of 49 patients with TTN (55.1%) did not receive any CXR, only diagnosed by LUS. CXRs were taken once for 21 (42.9%) patients and twice for one (2%) patient.

The first CXRs were taken in all patients (n=24) diagnosed with RDS for umbilical venous/ arterial catheter confirmation at approximately second hour of life. Second CXRs were taken in 15 of these patients (62.5%) to see lung expansion after the first surfactant treatment at median 8th hours. Third CXRs were taken in six patients with RDS after second dose of surfactant at median 14.5thhours. Surfactant treatment were given by less invasive surfactant administration method in infants on non-invasive ventilation.

CXRs were not taken in only two (7.4%) of the 27 patients with pneumonia, 18 (66.7%) of them had CXR taken once, and seven (25.9%) had CXR taken twice. Second CXRs were taken in these 7 infants for the confirmation of umbilical venous/ arterial catheter placement.

One (25%) of the four patients diagnosed with congenital heart disease did not have CXR taken, and three (75%) patients had CXR taken once.

CXR was not taken in 27 of the patients with a diagnosis of TTN, in 2 of the patients with a diagnosis of congenital pneumonia, and in one of the patients with congenital heart disease. Out of 104 infants 30 (28,8

%) infants who were admitted to NICU with respiratory distress were not evaluated with a CXR. Infants were evaluated with LUS 210 times on the first day of life. Patients with RDS 59 times, those with TTN 83 times, patients with congenital pneumonia 62 times, and patients with congenital heart disease 6 times were evaluated by lung ultrasonography.

The dose of a CXR taken in our unit is 4.35 µGy. The total amount of radiation the patients were exposed to due to the CXR taken was 465.5 µGy.

DISCUSSION

CXR has been considered the gold standard in the diagnosis of lung diseases, and it is a routine diagnostic tool for respiratory distress in newborns. All infants who were admitted to NICU with respiratory distress had to undergo CXR imaging at least once. However, CXR exposes the patients and the medical staff to radiation, and such exposure may be harmful to growing newborns and premature infants[11].

When the beam reaches the patient, it is absorbed by different tissues of the body in varying degrees, depending on the thickness and density of the target tissues. When the X-ray beam encounters the thicker parts of the body, these areas absorb a larger portion of the X-ray beam compared with the thinner areas.[12,13] Theoretically radiation can damage sections of DNA, suppress the division of cells in metaphase during mitosis, and cause mutation during meiosis. According to the law of Bergioner and Tribondeau, the radiosensitivity of tissues depend on the number of undifferentiated cells that the tissue contains, the degree of mitotic activity in the tissue, and the length of time that the cells of the tissue remain in active proliferation.[13] Patients undergoing fast rates of development, such as embryos, fetuses, and newborns, are far more vulnerable to the effects of radiation than adults. Schulze-Rath et al.[19] reported that antenatal and postnatal radiation exposure increased childhood cancers, especially non-Hodgkin lymphoma, leukemia, and solid tumors, in a dose-dependent manner. In a review, it was indicated that radiation-dependent cell damage increased linearly with the radiation dose.[20]

Use of LUS has become widespread in all NICUs in recent years. LUS has been widely used in our clinic for five years.[14,15] In this retrospective study, we observed a decrease in the number of CXRs, and thus radiation exposure, because of routine LUS use. Because no CXRs were taken in 30 babies, exposure to radiation was prevented in 28.8 of newborn infants. If we assume that, if only one CXR would be taken in these infants a total of 130.5 µGy doses of radiation dose will be added to total dose (107 CXR = 465.5 µGy). These means that reduced radiation exposure was approximately 22 %.

In a study performed in newborns between 24 and 36 weeks of gestation, a significant decrease in CXR was detected with the widespread use of LUS within two years.[10] They reported that in 2014, compared to 2012, exposure to radiation in premature babies decreased from 183 ± 78 µGy per baby to 68 ± 30 µGy a year. In their study the CXR ratio decreased from 81% to 69.7%. In addition, the rate of patients treated without X-rays taken was 30.3%. They evaluated total radiation exposure of the premature infants during NICU stay. The rate of the infants treated without CXR were similar (28.8%) in our study. However, study groups were significantly different since only the infants with respiratory distress were included in our study. In addition, we evaluated first day radiation exposure of preterm and term infants with respiratory distress in this study. First day of life is important since differential diagnosis of respiratory distress should be made and, necessary treatment should be given according to diagnosis. Arterial and venous access should be performed for monitorization of the infant and treatment. Most acute changes occur on the first day of life, for example surfactant treatment changes lung mechanics of preterm infants within hours and respiratory distress may ameliorate during transition period in late preterm infants and term infants. So, most of the CXRs are usually taken on the first day of life.

Diagnosis of RDS and decision of surfactant treatment are mostly dependent on the findings of LUS which was performed at second hours of life in this study[15]. CXRs which were taken at second hours of life were performed only to determine catheters' position, not for diagnose or treatment in patients with RDS. It can be concluded that the number of the CXRs taken on the first day of life can be decreased more than half if we can determine catheter placement by ultrasound.

In the neonatal population, the role of LUS in the diagnosis of pneumonia has not been studied extensively.[17] Liu et al.[18] determined the role of LUS in the diagnosis of pneumonia in the neonatal population. The sensitivity and specificity of LUS in congenital pneumonia were confirmed using CXR and clinical examination or medical history. We found that 7.4% of the patients diagnosed with congenital pneumonia were diagnosed using only LUS as the imaging method and that CXR was not required. It is expected that much more patient with pneumonia could be treated depending on LUS findings. Most of the neonatologists needed to confirm the diagnosis of pneumonia by CXR which was diagnosed by LUS. Probably some more experience is needed to treat pneumonia without taking CXR, depending on only LUS findings. This will lead the decrease in the amount of radiation exposed in NICU.

CONCLUSION

LUS is a practical, easily repeatable, and easy bedside imaging method that is used frequently. This study aimed to determine how much radiation exposure was reduced using routine LUS in infants in the first 24 h after birth. This retrospective study revealed that 28.8 % of the babies with respiratory distress were treated without CXR.

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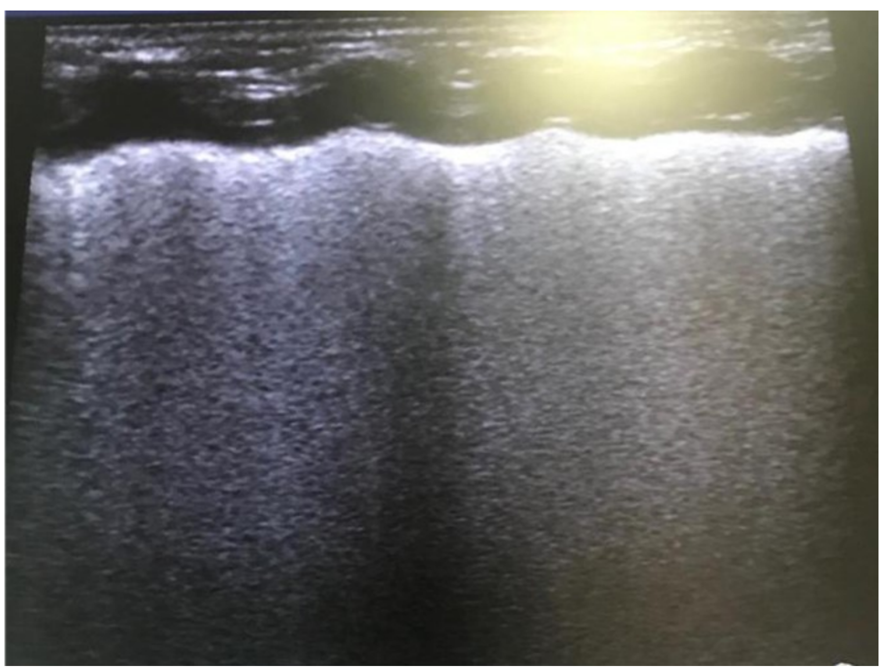
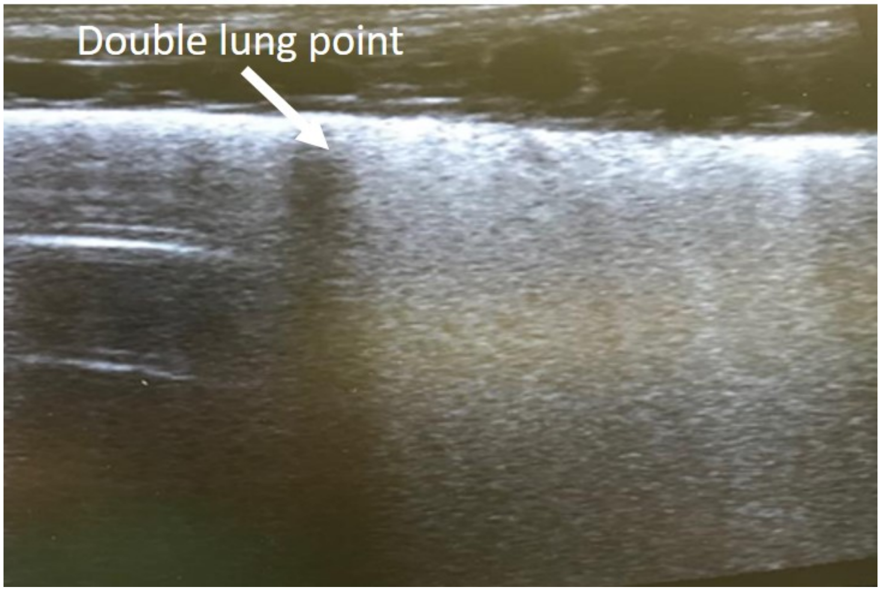
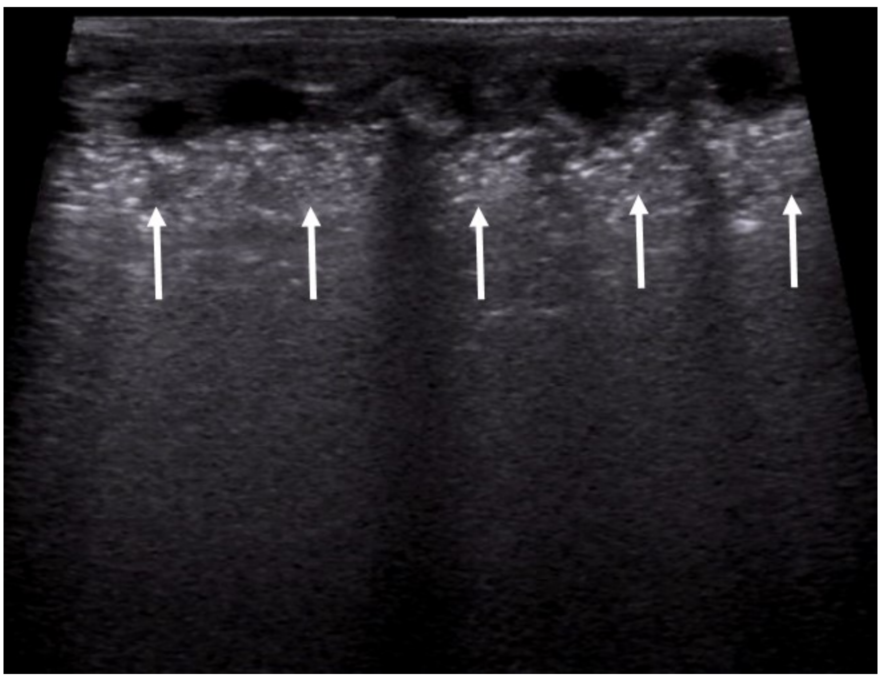
Figure 1: Respiratory distress syndrome. Ultrasound shows white lung appearance.

Figure 2: Transient tachypnea of newborn. Ultrasound shows a double lung point

Figure 3: Congenital pneumonia. Ultrasound shows multiple irregular consolidations with air bronchograms in the subpleural lung region (arrows) and disappearance of pleural line.







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