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● *Original Contribution*

USE OF LUNG ULTRASOUND IN DETECTION OF COMPLICATIONS OF RESPIRATORY DISTRESS SYNDROME

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Abstract—Repeated chest radiography is required for the diagnosis and follow-up of neonates with respiratory distress syndrome (RDS) and carries the risk of radiation hazards. Lung ultrasound (LUS) is a non-invasive bedside diagnostic tool that has proven to be effective in the diagnosis of RDS. Our aim was to assess the role of LUS with respect to the standard chest X-ray (CXR) in the detection of complications of RDS in neonates. Ninety premature newborns of both genders with RDS (mean gestational age = 29.91 ± 1.33 wk) and 40 premature babies as a control group were involved in this study. All patients underwent initial clinical assessment as well as CXR and LUS. Those who presented with respiratory distress and/or exhibited deterioration of oxygenation parameters were followed by CXR and, within 4 h, by LUS. Alveolo-interstitial syndrome and pleural line abnormalities were detected in all cases (100%) in the initial assessment, patchy consolidation was detected in 34 cases and white lung was detected in 80 cases. Alveolo-interstitial syndrome was detected in 19 controls. In follow-up of the patients, LUS was superior to CXR in detection of consolidation and sub-pleural atelectasis, but not in detection of pneumothorax. We concluded that bedside LUS is a good non-hazardous alternative tool in the early detection and follow-up of RDS in the neonatal intensive care unit; it could be of value in reducing exposure to unnecessary radiation. (E-mail: happy7_kd@yahoo.com) © **2015 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Respiratory distress syndrome, Premature newborns, Lung ultrasonography, Chest X-ray.**

INTRODUCTION

Neonatal respiratory distress syndrome (RDS) starts at or shortly after birth and increases in severity until progressive resolution among its survivors. RDS usually occurs between the second and fourth days after birth. It is due, at least in part, to insufficiency of pulmonary surfactant and is confined mainly to preterm infants (Copetti et al. 2008).

The incidence rate is 80% in infants <28 wk of gestation, 60% at 29 wk and 15%–30% at 32–34 wk and declines with maturity to 5% at 35–36 wk (Liu et al. 2014a). RDS also is observed in term infants, in whom its incidence varies between 3.6% (Liu et al. 2010) and 6.8% (Bouziri et al. 2007). The risk factors for occurrence of RDS in term infants include selective cesarean section, severe birth asphyxia and maternal–fetal infection (Liu et al. 2014c).

The diagnosis of RDS is usually based on clinical manifestations, arterial blood gas analysis and chest X-ray findings (Liu et al. 2014a). Repeated chest radiography is required for diagnosis and follow-up of patients with RDS and carries the risk of radiation hazards (Lichtenstein and Mauriat 2012). Lung ultrasonography (LUS) is a non-invasive bedside diagnostic tool that has proven to be effective in the diagnosis and follow-up of RDS and almost all its complications in neonates (Copetti and Cattarossi 2008). The availability of skilled neonatologists able to perform bedside LUS and eliminate the wait for a radiologist is another reason to emphasize the utility of LUS.

The aim of this study was to assess the role of LUS with respect to the standard chest X-ray (CXR) in the detection of complications of RDS in neonates.

METHODS

Ninety premature newborns of both genders with RDS (mean gestational age = 29.91 ± 1.33 wk) and a control group of 40 premature newborns (mean gestational age 34.22 ± 1.05 wk) without respiratory distress (lung diseases were excluded by clinical examination and CXR) were involved in this case–control prospective study. All patients were recruited into the study and

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managed in the neonatal intensive care unit (NICU) of Children's Hospital, Cairo University, between September 2012 and January 2014. This tertiary-care unit admits neonates born in the obstetric unit of the same hospital. The number of deliveries in this unit reaches as high as 1,000 to 1,500 per mo; the total number of NICU admissions throughout the study period was 350, with an average of 50 newborns per mo. The diagnosis of RDS was based on clinical and radiologic findings.

It should be noted that the infants in the control group had been admitted for other reasons (low birth weight, N = 27; maternal chorioamnionitis, N = 7; jaundice, N = 4; hypoxic ischemic encephalopathy, N = 2). Newborns with gestational age ≥37 wk, patients with congenital chest or heart diseases and neonates with hypoxic ischemic encephalopathy were excluded from this study (N = 24).

Approval was obtained from the research ethics committee of the Pediatric Unit at Cairo University. Data were confidentially preserved according to the Revised Helsinki Declaration of Bioethics. Informed written consent was obtained from the parents of the patients. Parents of 17 infants refused to have their children involved in the study.

The diagnosis of RDS was based on clinical, laboratory and radiologic criteria: clinical criteria (onset of symptoms within 6 hours of birth) included a respiratory rate >60/min, dyspnea characterized by intercostal, subcostal or suprasternal retraction, grunting or cyanosis; laboratory criteria included arterial blood gas levels indicating respiratory acidosis (pH <7.25, $PaCO_2$ >60 mm Hg, PaO_2 <50 mm Hg); radiologic criteria included CXR findings graded as follows: grade I = mild ground glass veiling; grade II = bilateral well-evident reticulonodular pattern; grade III = air bronchogram; grade IV = bilateral symmetric parenchymal opaqueness (white lung).

We encountered 14 patients who were grade I by CXR but did not fulfill other criteria for diagnosis of RDS, so they were excluded from the study. We also had 22 patients categorized as grade II, 22 patients as grade III and 46 patients as grade IV.

Gestational age, sex, mode of delivery, Apgar score at 1 and 5 min, birth weight, whether surfactant was required, whether positive pressure support was required (and method of positive pressure support), duration of stay and fate (death or discharge) were recorded.

All patients underwent an initial assessment when they presented with respiratory distress. This assessment comprised (i) clinical assessment of respiratory distress, auscultation of chest and exclusion of other systems affected; (ii) radiologic assessment by CXR and LUS (LUS was done within 4 h after CXR); (iii) collection of a venous blood sample for complete blood count and qualitative assessment of C-reactive protein and another arterial sample for measurement of arterial blood gases; and (iv) echocardiography to exclude congenital heart diseases and persistent pulmonary hypertension.

Patients were followed clinically during their stay in the NICU according to our unit protocol. CXR was performed for the following clinical indications: development of dyspnea, respiratory rate >60/min, grunting and cyanosis and/or worsening of oxygenation parameters. After establishment of proper respiratory status, LUS was performed within 4 hours of a supine anteroposterior CXR by another investigator (radiologist) who was blinded to the CXR findings. The CXR was performed with the Philips Mobile Medical X-ray system D-22335 (Philips, Hamburg, Germany).

Lung ultrasonography technique

Lung ultrasonography was performed with a Toshiba Diagnostic Ultrasound System Nemio XG SSA-580A, using a linear 7-MHz probe (Toshiba, Tokyo, Japan). Lung regions that were explored by auscultation were also examined by ultrasonography. The sonographer scanned the anterior, lateral and posterior chest walls. Images of longitudinal and transverse sections were obtained. On the anterior chest, transverse sections were obtained by positioning the probe transversally, from the second to the fifth intercostal spaces; longitudinal sections were obtained by positioning the probe longitudinally, along the parasternal, mid-clavicular, anterior axillary and mid-axillary lines. On the posterior chest wall, transverse sections were obtained by positioning the probe on the intercostal spaces below the scapular spine; longitudinal sections were obtained along the para-vertebral, scapular and posterior-axillary lines.

Definitions of pathologic lung ultrasound findings

1. A pleural line is an echogenic line that lies between the two shadows of the ribs and represents the pleural surface (Gardelli et al. 2012). Pleural line abnormalities are defined as thickening (>0.5 mm), irregularity or coarsening or the presence of small sub-pleural consolidation patches (Fig. 1a) (Copetti et al. 2008).
2. The quad sign (Fig. 1b), anechoic pleural fluid trapped between the echogenic pleural line and the roughly parallel lung surface (Lichtenstein and Mauriat 2012), indicates pleural effusion.
3. The tissue-like sign indicates lung consolidation (Fig. 1), in which the airless sub-pleural, consolidated lung appears as a large, iso-echoic, wedge-shaped area with an internal-branching, echogenic, linear air bronchogram. An echogenic branching air bronchogram that appears parallel, crowded or condensed suggests