Lung ultrasound in follow-up of low birth weight with respiratory distress syndrome: clinical application and reduction of x-rays examinations

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Purpose

1. Respiratory distress syndrome (RDS) is the most common clinical syndrome in infants hospitalized in neonatal intensive care unit (NICU) and has its own, very specific diagnostic algorithm and therapy. The etiology is linked to delayed maturation of the synthesis of surfactant associated with structural lung immaturity, characterized by incomplete development of the alveoli and an excess of connective tissue matrix. The diagnosis of RDS is mainly based on clinical findings, on blood gas analysis and on chest radiograph.

2. The radiographic findings reflect the clinical picture of generalized collapse acinar due to deficiency of surfactant (Figure 1). The chest radiograph in addition to being a valuable tool for the diagnosis of RDS is necessary to monitor the therapeutic response and possible complications. The use of ionizing radiation, however, is not without risk, especially in this patient which harmful effects may be similar to those induced in the fetus of the same gestational age.

3. Chest ultrasound, until now, had only limited applications. It is known that the air contained in the lungs prevents the progression of ultrasound and normal lung images consist in artifacts. Only recently some authors have considered chest ultrasound valid in some of the newborn lung diseases such as transient tachypnea (TTN) and RDS.

4. Our study aimed to evaluate the reduction in the number of chest radiographs in infants with respiratory distress after having introduced the systematic use of chest ultrasound. We want to demonstrate the possibility to assess the performance of RDS by ultrasound method with the intent to obtain the reduction level of exposure to ionizing radiation in NICU.
Fig. 0: X-ray: poorly ventilated lung, nodular aspect 'ground glass'

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Methods and Materials

From April 2008 to September 2008 were performed 105 chest ultrasound in 21 patients hospitalized in neonatal intensive care unit with RDS diagnosis. The gestational age (GA) ranged from 25 weeks + 5 days to 32 weeks + 6 days (30 ± 2, mean ± SD) with birth weight varied from 668 g to 1440 g (1159 ± 283 g, mean ± SD). During this period, were performed 56 radiographs an average of 2.6 ± 1 X-rays for patient (Group I). These data were compared with those obtained in patients consecutively admitted with RDS diagnosis in the six months immediately prior to the ultrasound study. This group was characterized by 18 patients with GA between 26 weeks + 1 day and 32 weeks + 4 days (29.1 ± 1.85 weeks, mean ± SD) and weight ranged from 810 g to 1635 g (1204 ± 223 g, mean ± SD) (Group II) (Table 1). In this group were executed 69 X-rays with an average of 3.8 ± 1.5 tests for patient (p <0.05).

Table 1: Clinical data of the two groups

<table>
<thead>
<tr>
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<th>Group I</th>
<th>Group II</th>
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<tbody>
<tr>
<td>Patients (n)</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>Gestational age</td>
<td>30 ± 2</td>
<td>29.1 ± 1.85</td>
</tr>
<tr>
<td>(weeks)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (g)</td>
<td>1159 ± 283</td>
<td>1204 ± 223</td>
</tr>
<tr>
<td>X-rays</td>
<td>2.6±1</td>
<td>3.8±1.5</td>
</tr>
</tbody>
</table>

Each neonate in Group I with clinical and radiological evidence suggestive of RDS underwent chest ultrasound study.

Radiological method

First X-ray was performed for all patients to confirm the RDS diagnosis. In follow-up control X-ray was executed only in case of discrepancy between clinical condition and ultrasound pattern.

Ultrasound method

The ultrasound scans were effected with 7.5-MHz linear probe for trans-thoracic scanning. Longitudinal (Figure 1) and transverse scans of the entire chest wall were used; video clip recording and photographing images, on mid-clavicular line and mid-axilla bilaterally, was considered the standard images for subsequent revaluations. After clinical and radiological diagnosis of RDS the neonates have chest ultrasound every 8-12 hours until the disease resolution.
ULTRASOUND NORMAL LUNG

Chest ultrasound in neonates is not very different from adults.

Skin, subcutaneous tissue and muscles of the chest wall are the first layers in ultrasound images. The ribs in the longitudinal scans are detected as curvilinear hyperechoic structures with characteristic posterior shadow cone; the pleura appears as a smooth hyperechoic line (Figure 2) which has a synchronous movement with breathing acts. The pleural movement has been described as 'lung sliding sign' and its absence is particularly useful in the diagnosis of pneumothorax. Beneath the pleura lung interface, the air in the alveoli does not allow visualization of normal lung parenchyma. In fact, the high acoustic impedance between soft tissue surface and the air contained in the lungs creates a total reflection of the ultrasound beam generating horizontal artifacts. Horizontal artifacts lines (A lines according to Lichtenstein) are hyperechoic lines parallel to the ultrasound scan plane equidistant from each other. In the normal lung will also show rare artifacts such as 'comet tail' reverberation lines, vertical lines (Lichtenstein B lines), that come from the pleural line to the depth of the ultrasound image. In many pulmonary diseases the air into the alveoli is reduced and the ultrasound picture changes.
Images for this section:

Fig. 0: Mid-clavicular longitudinal scan in patient hospitalized in TIN.

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**Fig. 0:** Longitudinal scan of the thorax: Normal lung. The ribs determine a posterior shadow cone, the pleural line (vertical arrows) is visible below the chest wall between the two coasts. Horizontal lines (curved arrows) are equidistant from each other.

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Results

Neonates with clinical and radiological RDS, ultrasound feature is characterized by the presence of B lines (Figure 1) associated, in some cases, with irregularity of the pleural line. Below the pleural line, in severe cases, pulmonary artifacts are replaced by small hypoechoic areas (Figure 2), expression of atelectasis areas. All 21 patients had an image in which the B lines were close together, evenly distributed in both lungs, making the image almost completely hyperechoic (compact B lines). In 8 cases there were a thickening of the pleural line (Figure 3), which also appeared irregular; in 7 cases were observed hypoechoic sub-pleural areas, mainly in the lateral portion of the lung, consistent with areas of pulmonary consolidation (Table 2).

Table 2: Ultrasound features

<table>
<thead>
<tr>
<th>Features</th>
<th>Patient number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact B lines</td>
<td>21</td>
</tr>
<tr>
<td>Thickened pleural line</td>
<td>8</td>
</tr>
<tr>
<td>Irregular pleural line</td>
<td>7</td>
</tr>
<tr>
<td>Sub-pleural areas</td>
<td>7</td>
</tr>
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</table>

Once recorded on videotape the ultrasound picture was easy to find the pathological transition to the phase of 'healing' when, in ultrasound images, returning the artifacts to be displayed 'physiological' horizontal artifacts (A lines), typical of healthy lung. During the study period the X-ray control was reserved only for infants who showed a discrepancy between ultrasound and clinical status. In NICU the use of lung ultrasound has reduced significantly the number of X-rays and therefore exposure to ionizing radiation in neonates with RDS. In fact, it is found by a reduction in the number of radiographs for patient, from an average of 3.8 ± 1.5 in the previous six months to 2.6 ± 1 in the study group.
**Fig. 0:** Longitudinal scan of the chest: RDS. compact B lines (arrows) between the ribs (curved arrows).

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Fig. 0: Intercostal transverse scan of thorax: pleural line appear irregular (arrow) with hypoechoic sub-pleural area (arrowhead).

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Fig. 0: Longitudinal scan of the thorax in RDS: pleural line is thickened.

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Conclusion

The RDS is a common clinical syndrome in NICU and requires the use of the chest X-ray for a complete diagnosis. It is not uncommon that is necessary more than an X-ray during hospitalization to assess the effectiveness of therapy. In our study, we applied a routine ultrasonography in the follow-up to the RDS with the evidence of characteristic sonographic pattern. This method reduces the number of radiographs required for the follow up of patients with RDS thereby reducing the exposure to ionizing radiation.
References

16. European guidelines on quality criteria for diagnostic radiographic images in paediatrics. EUR 16261 EN