Radiology of neonatal respiratory distress

Poster No.: C-0173
Congress: ECR 2013
Type: Educational Exhibit
Authors: L. Raposo Rodríguez, G. Anes, S. González Sánchez, A. M. Benítez Vazquez, A. Velasco Bejarano, E. S. Morales Deza; Oviedo/ES
Keywords: Thorax, Acute
DOI: 10.1594/ecr2013/C-0173

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Learning objectives

Due to the physiological characteristics of the lungs of preterm and full-term newborns, lung diseases in neonates, along with their radiologic manifestations, differ significantly from those affecting the adult.

The respiratory distress syndrome in newborn may have many different causes with very similar clinical manifestations, so the chest radiograph continues to be the most useful diagnostic test.

We can conclude that it is important to have a good knowledge of the imaging features related to the different causes of respiratory distress in newborns.
Background

SURFACTANT DEFICIENCY DISEASE:

Surfactant deficiency disease affects mainly newborns of less than 36 weeks’ gestation weighing less than 2.5 kg. It is associated with both biochemical lung immaturity secondary to surfactant deficiency and with structural lung immaturity.

Surfactant being a lipoprotein that reduces surface tension, absence of this substance causes an increase of surface tension in the alveoli which leads to a persistent alveolar collapse.

Neonates with respiratory distress usually present with clinical manifestations within 2-3 hours, or even immediately, after birth, although clinical presentation can be delayed up to 6-8 hours.

The characteristic imaging finding is lung granularity Fig. 1 on page , related to the presence of distended bronchioli, atelectatic alveoli and acinar nodules, associated with generalised hypoventilation. More severe cases of the disease will exhibit alveolar atelectasi converging around the dilated bronchioli, depicting an air bronchogram image and eventually, in the most severe cases, a lung white-out.

Nowadays, surfactant replacement therapy rapidly restores lung aeration with a remission of the imaging findings that can be irregular.

Complications of surfactant deficiency disease:

AIR BLOCKAGE:

In premature infants, lung immaturity along with surfactant deficiency disease itself and positive-pressure mechanical ventilation, used to treat this disorder, cause an increase in transalveolar pressure. This increased pressure leads to alveolar rupture, gas consequently dissecting into peribronchial and perivascular spaces, sometimes reaching the mediastinum or the pleural space.

- Pulmonary interstitial emphysema is due to an air collection in peribronchial and perivascular spaces and it radiologically manifests as round or tortuous and linear radiolucencies irradiating from the hilum to the rest of the lung Fig. 4 on page . Progression of this emphysema can lead to the presence of a pulmonary pseudocyst.

- Pneumomediastinum; air from interstitial emphysema may reach the mediastinum causing a pneumomediastinum, which usually has no clinical significance.
Frontal chest radiograph may exhibit a radiolucent line outlining both sides of the cardiac contour Fig. 5 on page . "Continuous diaphragm sign", due to the presence of air under the heart, may also be identified. Mediastinal air may elevate the lobes of the thymus depicting the "spinnaker sail sign" Fig. 6 on page . The lateral chest radiograph will confirm the pneumomediastinum and in up to 50% of cases diagnosis will only be possible in this projection.

- Pneumothorax occurs when the interstitial emphysema reaches the pleural space. It is usually a tension pneumothorax with contralateral mediastinal shift, flattening or inversion of the diaphragm and increased intercostal spaces Fig. 7 on page .

- Pneumoperitoneum; sometimes mediastinal air may dissect into the abdomen causing a pneumoperitoneum Fig. 8 on page or pneumoretroperitoneum.

**BRONCHOPULMONARY DYSPLASIA AND WILSON-MIKITY SYNDROME:**

Bronchopulmonary dysplasia and Wilson-Mikity syndrome are similar disorders, characterized by overdistention in some alveoli and atelectasia in some others, which leads to a reticular pattern Fig. 9 on page and to the eventual formation of air-filled cavities Fig. 10 on page .

Bronchopulmonary dysplasia is related to oxygen toxicity and the damage secondary to mechanical ventilation, while Wilson-Mikity syndrome affects normal newborns.

**Fig. 10:** Bronchopulmonary dysplasia. Fig. A, onset reticular pattern. Figs. B, C and D, chest radiograph and minimum-intensity CT reconstructions that show the progression of the disease with presence of multiple air-filled cavities.

References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

**LEAKY LUNG SYNDROME:**

Leaky lung syndrome occurs in low-birth-weight preterm newborns (especially those weighing less than 2.5kg) who have suffered from a severe hypoxia and have been treated with mechanical ventilation and high flow oxygen. Under these circumstances, lung capillaries are damaged, showing an increased permeability. Consequently, after recovery from surfactant deficiency disease, the increased permeability in the capillaries leads to transudation of fluid into the interstitium and finally into the alveolar space.

Leaky lung syndrome is associated with bronchopulmonary dysplasia. Although they are two different entities the leaky lung predisposes to a prolonged ventilation and therefore to the development of bronchopulmonary dysplasia.

Radiologically, this syndrome is characterized by a refractory course of the surfactant deficiency disease with persistency of lung opacity. Usually, when a pulmonary oedema
is developed lungs exhibit a larger volume than in surfactant deficiency disease Fig. 11 on page .

RETAINED FETAL LUNG LIQUID (RFLL) OR TRANSIENT TACHYPNEA OF THE NEWBORN:

RFLL results from delayed clearance of fetal lung fluid. This condition is more common in newborns delivered by caesarean section, likely because the compression exerted on the thorax when passing through the birth canal facilitates the clearance of the lung fluid.

Symptoms and signs of respiratory distress usually appear 2-4 hours after birth and resolution is often achieved within 24 to 48 hours under conservative treatment.

Characteristic imaging findings include: bilateral and symmetric perihilar infiltrate Fig. 12 on page , large lungs and sometimes pleural effusion.

MECONIUM ASPIRATION:

Intrauterine fetal stress causes the usual weak fetal breathing to become deep and facilitates meconium to be released by fetus. The result is the aspiration of a mixture of amniotic fluid and meconium.

Meconium aspiration is more common in postterm newborns and presents with respiratory distress immediately after delivery.

The aspirated meconium impacts on peripheral bronchioles causing air trapping. Therefore, imaging tests will exhibit marked pulmonary hyperinflation with bilateral nodular infiltrates representing atelectatit areas Fig. 13 on page .

Air blockage complications are also frequent.

PULMONARY HAEMORRHAGE:

Pulmonary haemorrhage is secondary to the hypoxia and subsequent capillary damage present in surfactant deficiency disease, meconium aspiration, bronchopulmonary dysplasia and congenital heart diseases.

A mild haemorrhage may not be visible on the chest radiographs, whereas a severe one will show diffuse lung opacity Fig. 14 on page .
Fig. 1: Fig. 1: Mild surfactant deficiency disease, diffuse bilateral granular pattern. References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

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Fig. 2: Moderate surfactant deficiency disease, diffuse bilateral granular pattern and air bronchograms References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES"
**Fig. 3:** Severe surfactant deficiency disease, white lung. References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

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Fig. 4: Interstitial emphysema in a patient with surfactant deficiency disease. The right lung shows linear and round radiolucent lesions irradiating from hilum. The left lung exhibits atelectasis. References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

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Fig. 5: Fig. 5: Surfactant deficiency disease. Pneumomediastinum manifested as a radiolucent lesion outlining the right cardiac contour. Right pneumothorax. Complete atelectasis of the left lung secondary to the location of the endotracheal tube in the right mainstem bronchus. References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

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Fig. 6: Spinnaker sail sign. Pneumomediastinum that elevates the thymus.
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**Fig. 7:** Fig. 7: Surfactant deficiency disease. Left tension pneumothorax causing contralateral mediastinal shift. References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

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Fig. 8: Massive pneumoperitoneum in a patient suffering from surfactant deficiency disease. References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

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Fig. 9: Fig. 9: Displasia broncopulmonar en fase inicial, patrón pulmonar reticular. References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

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**Fig. 10:** Bronchopulmonary dysplasia. Fig. A, onset reticular pattern. Figs. B, C and D, chest radiograph and minimum-intensity CT reconstructions that show the progression of the disease with presence of multiple air-filled cavities. References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

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**Fig. 11:** Patient with leaky lung syndrome. Premature infant presenting mild surfactant deficiency that had shown a refractory course with development of a pulmonary oedema. References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

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Fig. 12: Full-term newborn presenting with clinical manifestations of respiratory distress two hours after birth along with retained fluid syndrome. The first radiograph exhibits bilateral and symmetric perihilar infiltrates that resolved within 24 hours. References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

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Fig. 13: Amniotic fluid aspiration. Severe lung hyperinflation accompanied by inversion of the diaphragm and multiple nodular areas of opacity. References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

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Fig. 14: Newborn with pulmonary haemorrhage and escape of blood from the endotracheal tube. Bilateral diffuse lung opacification. References: Radiology Department, Hospital Universitario Central de Asturias - Oviedo/ES

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The respiratory distress syndrome in newborn may have many different causes with very similar clinical manifestations, so the chest radiograph continues to be the most useful diagnostic test.
Conclusion

Causes of respiratory distress in the newborn are numerous and imaging tests play a vital role in identifying most of them. Therefore, management of these patients will require a good knowledge of the imaging tests.
References

