

Neonatal Chest Radiography for Technologists

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Radiology

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Objectives

1. Describe a good technique for positioning a neonate for the purpose of obtaining a chest radiograph, which will allow serial exams to be compared without compensating for changes in rotation.
2. Describe the desired locations for the various tubes and lines that are placed during the newborns intensive care stay.
3. Explain the appearance of some of the more common neonatal chest abnormalities, such as hyaline membrane disease, bronchopulmonary dysplasia, pulmonary hypoplasia and congenital diaphragmatic hernia.

Article

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High quality care of the newborn with respiratory distress is dependent upon the availability of consistent high quality radiographic examinations of the chest. The technologist and the newborn unit personnel play an essential role in providing these studies.

Technical Issues:

Almost all infant chest radiographs are done within the nursery. In our newborn intensive care unit, it is a policy that all frontal films are obtained with the patient supine, the arms extended above the head, and the pelvis stabilized in a frontal position by a nurse or an assistant ([figure 1](#)). The person restraining the patient wears a lead apron and the technologist insures that the direct beam does not include any part of the assistant's hands. When using these precautions, there is no detectable radiation to anyone restraining infants on an occasional basis. Holding the infant ensures that consistent positioning in the frontal projection is achieved. This allows serial exams to be compared without compensating for changes in rotation.

It is also essential that technique factors be standardized for each patient. If at all possible, a single portable unit should be used for all neonatal x-ray procedures. Tube-film distance should be kept constant at about thirty-six to forty inches and exposure and kVP be recorded for each examination so that the film density does not vary significantly between studies.

Chest radiographs should be limited to the chest, which (approximately) is from the level of the infant's chin down to the umbilicus. The practice of routine "babygrams" should be discouraged. This unnecessarily increases radiation exposure to the patient and decreases the quality of the examination. The one exception is in films obtained immediately following the placement of umbilical lines because they often may either be purposely directed into the lower abdomen or inadvertently travel into the pelvis.

Assessment of Tubes and Lines:

Although it seems mundane, probably the most important function of neonatal chest radiography is to assess positions of the multiple tubes and lines that are placed during the course of the neonate's intensive care stay (figure 2). The endotracheal tube (ETT) should be located somewhere between the suprasternal notch and the carina. This corresponds with the second through fifth thoracic vertebra (approximately). With the head restrained in the neutral or AP position the tip of the ETT is actually about one half to one centimeter lower than it would be with the head turned to the side.

Umbilical artery catheters are usually placed either "high" between the sixth and tenth thoracic vertebra or low, at approximately the level of the aortic bifurcation (or about L3-L4).

The umbilical venous catheter (UVC) is usually positioned at the base of the right atrium. Depending upon the size of the liver and any degree of rotation of the patient, the umbilical venous catheter may appear to be right or left of the midline. The umbilical artery catheter (UAC) always parallels the spine.

All of these catheters and tubes are radiopaque and do not require contrast injection for localization. Standard technique will demonstrate the positions of the endotracheal tube and vascular lines. There is no need to purposely over expose a film that has been obtained for verification of line placement.

Pulmonary Diseases of the Premature Infant:

The most common diagnosis in premature infants admitted to the newborn intensive care unit is known as Hyaline Membrane Disease (HMD) or Idiopathic Respiratory Distress Syndrome (IRDS) (figure 2). This disorder most often occurs in premature infants that are less than thirty-four weeks gestation and represents a deficiency in production of a substance known as surfactant. Surfactant is a substance produced by the lung that allows the alveoli to easily re-expand after expiration. Without surfactant, a tremendous amount of effort is required to re-open these alveolar spaces. Surfactant deficiency results in lungs that appear hypoventilated. They are often described as appearing like "ground glass" and there is usually air bronchogram formation seen at the periphery. Administering corticosteroids to the mother during premature labor and giving exogenous surfactant via the endotracheal tube to the infant can significantly decrease the severity of HMD.

Today, most uncomplicated cases of HMD do not required more than one to two days of respirator therapy. Some premature infants have a more complex course and require prolonged intubation resulting in a higher risk for other complications. Common problems include atelectasis, which is often due to malposition of the ETT, and pneumothorax, which may be a complication of high ventilator pressures. Atelectasis is characterized by opacification of the affected lung or lobe and a shift of mediastinal structures to the affected side. Pneumothorax is often difficult to diagnose on supine films. The affected hemithorax is usually relatively lucent and there may be a shift in mediastinal structures to the opposite side.

In cases where the diagnosis of pneumothorax is uncertain, the best view is the lateral decubitus with the suspected side for the abnormality up. Air in the pleural space should then rise to the upper most portion of the chest. A cross table lateral view of the chest (which is often obtained) is of limited value since it cannot distinguish between pneumothorax and pneumomediastinum

As HMD begins to resolve some premature infants may go into heart failure because of abnormal blood flow through the Patent Ductus Arteriosus (PDA). The ductus arteriosus is a fetal communication between the aorta and pulmonary artery. When a baby is inside its mother's womb, blood that is full of oxygen returns to the baby from the placenta and enters the heart. Because the baby is not breathing inside the uterus, the oxygenated blood that is pumped to the lungs by the right heart passes through the ductus to the aorta so it can circulate through the rest of the baby's body. After delivery, the ductus arteriosus is suppose to close off so that the blood coming from the right ventricle does not circulate through the newborn's lungs in order to obtain the necessary oxygen. However, the premature infant's PDA may stay open and allow blood to flow from the aorta into the pulmonary artery when the HMD becomes less severe and there is a decrease in resistance to flow through the lung. Radiographically, this manifests as an enlargement of the heart with diffuse infiltrates, typical of pulmonary edema. This complication usually responds to medical management, which is a combination of fluid restriction, diuretics, and the anti-inflammatory drug Indomethacin, which promotes closure of the PDA. When these measures do not succeed then surgical ligation of the PDA is required. This is probably the most commonly performed thoracic surgical procedure in newborn infants.

Newborn infants who do have a complicated hospital course with hyaline membrane disease and heart failure often develop chronic lung changes. These abnormalities are termed Bronchopulmonary dysplasia (BPD). The appearance of BPD on a chest radiograph is variable, but in general, the infiltrates are coarse and the lungs are hyper expanded. This disorder is especially common in infants who were extremely premature and were supported on the respirator for a long period of time. Eventually

these x-ray changes usually resolve, although there may be long lasting pulmonary function abnormalities that persist into adulthood.

Pulmonary Disorders of the Term Infant:

In general, term infants have few serious pulmonary problems. The most common is known as Transient Tachypnea of the Newborn (TTN) or Retained Lung Fluid (RLF). This basically represents a manifestation of a normal physiological process. The lungs of all fetuses are filled with amniotic fluid and this fluid is supposed to rapidly clear following delivery. When the process of clearing this fluid from the lung after the delivery is prolonged, it is termed RLF or TTN. These infants usually have a rapid respiratory rate or tachypnea but otherwise appear well. Radiographically the heart may be mildly enlarged and there is usually some prominence of the pulmonary vasculature with perihilar infiltrates that are similar to those seen with pulmonary edema. The clinical and radiographic findings usually resolve without specific therapy.

TTN is more commonly recognized in infants delivered by cesarean section, since part of the process of removing the amniotic fluid from the lung may be related to squeezing of the chest as it passes through the birth canal during vaginal delivery.

The most common serious pulmonary disorder in term infants is sepsis or pneumonia. This actually represents a systemic infection, which may be acquired either prenatally or shortly after delivery. The radiographic findings are nonspecific and may even be negative. It is a misconception to use the term "pneumonia" in newborn infants, because even healthy ones at term are essentially immuno-compromised hosts and cannot localize infection to the lung as happens to older children or adults. For this reason the radiographic findings are often nonspecific or normal. The diagnosis is one of exclusion, and the radiograph primarily serves to eliminate other possible causes of respiratory distress.

Congenital, structural disorders of the chest are less common than the diseases mentioned above. However, they are important causes of neonatal morbidity and are often readily diagnosed from the chest x-ray. These diseases are now often discovered in utero, during routine obstetrical ultrasound examinations.

One of the most important congenital anomalies is Congenital Diaphragmatic Hernia (CDH) (figure 3). This is due to a defect of the hemi-diaphragm, which allows the bowel and abdominal organs to herniate into the chest. If the herniation is large and occurs early in fetal development, there can be hypoplasia of one or both lungs. In an effort to minimize the complication of pulmonary hypoplasia, which is often lethal, some cases of CDH are repaired in utero.

The chest x-ray findings in CDH are characteristic. Within several minutes to an hour after delivery a chest radiograph will show air filled loops of bowel within the affected hemithorax (most often seen on the left side). The prognosis is mainly due to the degree of pulmonary hypoplasia, and even with the best surgical techniques, neonatal mortality is on the order of fifty percent.

Other structural disorders, which can be diagnosed in utero and may be seen in a newborn chest radiograph, include cystic adenomatoid malformation (a disorder of abnormal lung development), pulmonary sequestration (a disorder where a section of lung obtains its blood supply from the systemic circulation instead of the pulmonary circulation) and hydrops fetalis.

Congenital Heart Disease:

Many forms of congenital heart disease can be diagnosed in utero, especially if there is a family history and a directed obstetrical ultrasound examination is performed. The radiographic findings in neonatal congenital heart disease are varied and rarely yield a specific diagnosis.

However, they do provide important information critical to the care of the patient. Again, excellent radiographic technique is required to assess heart size, pulmonary blood flow and other findings that direct the management of the patient. The precise diagnosis of the type of congenital heart malformation is now usually made with the use of pediatric echocardiography.

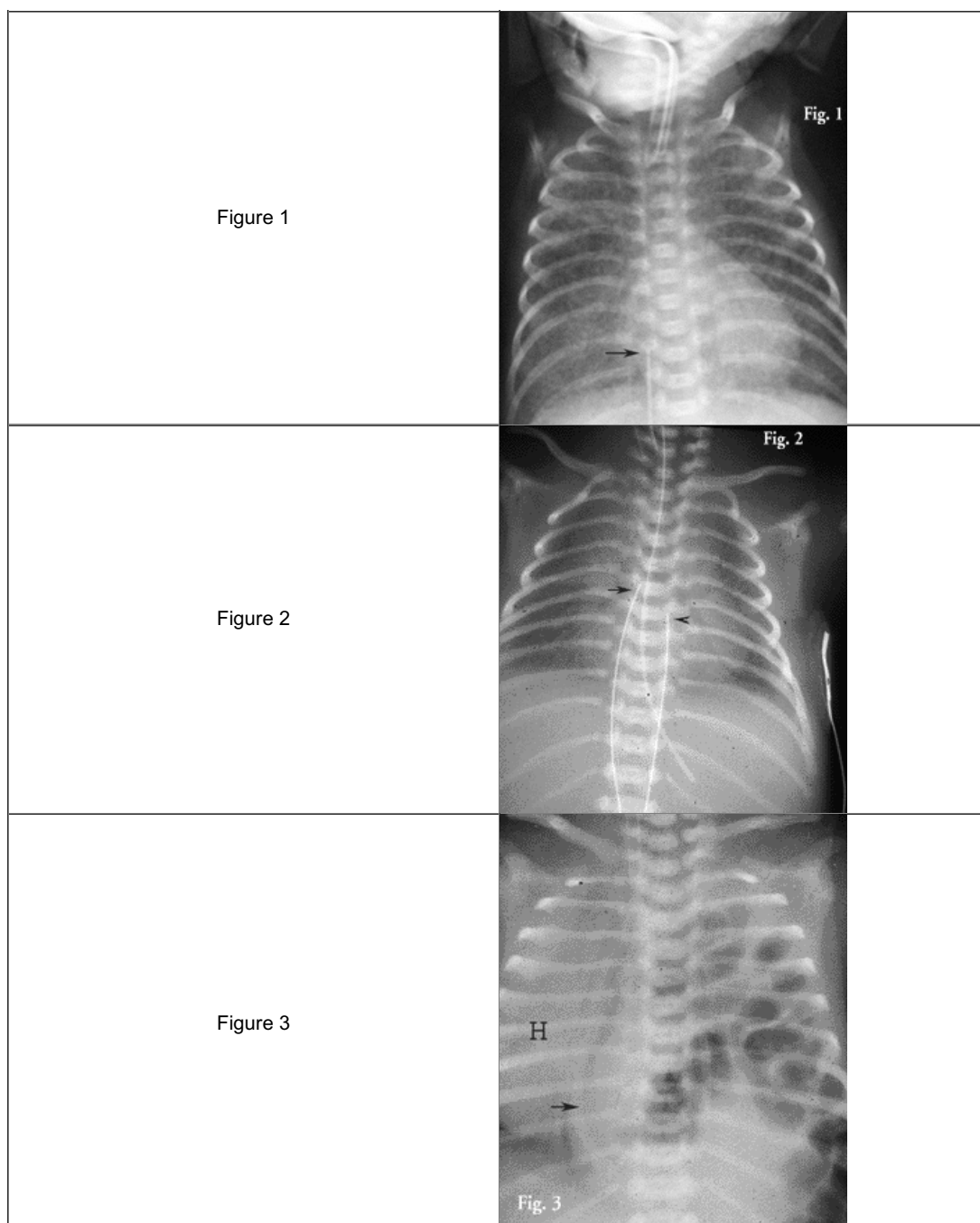
Pulmonary Hypoplasia:

Pulmonary Hypoplasia or under development of the lung is a rare congenital malformation which can be either unilateral or bilateral. It may be idiopathic or secondary to other diseases. One of the most commonly recognized causes for this disorder is fetal renal insufficiency resulting in oligohydramnios (which is a lack of amniotic fluid surrounding the baby). At birth, these

infants present with severe respiratory distress and require resuscitation. The initial chest radiograph will often demonstrate what appears to be bilateral pneumothoraces. The prognosis for these infants is generally poor and is usually determined by the degree of pulmonary hypoplasia and the severity of the underlying cause for its development (for example renal agenesis, etc.).

Figures:

1. A preterm infant restrained with the hands held above the head. The chest is not rotated and the exposure is optimal. Pulmonary infiltrates, heart size and the positions of the endotracheal tube and umbilical venous catheter (arrow) are clearly demonstrated.
2. Multiple tubes and lines in a preterm infant with hyaline membrane disease (HMD). The ETT tip is in the neck and should be advanced downward. The UVC (arrow) overlies the upper right atrium and should be pulled back. The UAC is at the level of the sixth thoracic vertebra. A nasogastric tube (NG) extends below the diaphragm. Note that a metal electrode is positioned on the lateral chest so that possible pathology will not be obscured.
3. A newborn that has congenital diaphragmatic hernia. Multiple air-filled loops of bowel are seen in the left hemithorax. The heart (H) and air filled esophagus (arrow) are shifted to the right. Only a small amount of normal appearing lung is evident in the right lower chest.



References or Suggested Reading:

1. Practical Approaches to Pediatric Radiology. Andrew K. Poznanski. Yearbook Medical Publishers, 1976.
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About the Author(s)

Dr. Diament is an Associate Professor of Radiological Sciences at the University of California, Los Angeles. He is currently the Director of Pediatric Radiology at Harbor UCLA Medical Center. Dr. Diament is Board certified by the American Board of Radiology and has been certified in Pediatric Radiology and Vascular/Interventional Radiology. In the past, for four years, he was the Chairman of the Radiation Safety Committee at Children's Hospital of Los Angeles and for 6 years served on the Publications Committee of the Los Angeles Radiological Society.

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