Multidetector computed tomography evaluation in neonatal respiratory distress: Clinical implication

Eman Abo Elhamd a, Gehan S. Seifeldein a,*, Nafisa H.R. AbdelAziz b

a Department of Radiology, Assiut University Hospital, Egypt
b Department of Pediatrics, Assiut University Children Hospital, Egypt

Received 8 June 2012; accepted 11 December 2012
Available online 16 January 2013

Abstract Objective: To assess the value of multiplanar reformation (MPR) and three-dimensional multidetector computed tomography (MDCT) images in evaluating respiratory distress in neonates. Materials and methods: Sixteen neonates (≤30 days) who presented with respiratory distress (RD) and admitted in the neonatal intensive care unit of the Assiut university children hospital who were selected from a total of 1295 patients presented with RD in whom chest X-ray was inconclusive, so those 16 neonates underwent 64-rows MDCT in the period between November 2010 and November 2011. The recruited patients were sedated before examination and IV contrast medium administration was needed when there was suspected vascular anomaly. Scans were performed in supine position to cover the root of the neck down to the level of the adrenal glands. The images were sent to the workstation to be reviewed in the multiplanar and 3D images.

Results: The final radiologic diagnoses included cystic adenomatoid malformation (n=4, 25%), congenital lobar emphysema (n=1, 7%), pneumonia (n=5, 36%), hypoplastic lung (n=3, 22%), diaphragmatic hernia (n=2, 14%) and postoperative hydro-pneumothorax (n=1, 7%).

Conclusion: The combination of fast speed, high spatial resolution, and enhanced quality of MPR and 3D images makes MDCT an ideal non-invasive method for evaluating surgical causes of neonatal respiratory distress.

1. Introduction

The clinical presentation of respiratory distress in the newborn includes apnea, cyanosis, grunting, inspiratory stridor, nasal flaring, poor feeding, and tachypnea (more than 60 breaths per minute). There may also be retractions in the intercostal, subcostal, or supracostal spaces. Respiratory distress occurs in approximately seven percent of infants (1). Most cases are caused by transient tachypnea of the newborn, respiratory distress syndrome, or meconium aspiration syndrome, but...
various other causes are possible such as pneumothorax, delayed transition, infection (e.g., pneumonia, sepsis), nonpulmonary causes (e.g., anemia, congenital heart disease, musculoskeletal abnormalities of the chest, lesions of the diaphragm and abdomen, medications, neurologic or metabolic abnormalities, polycythemia, upper airway obstruction), and persistent pulmonary hypertension of the newborn (2). Chest radiograph can help to differentiate between them. These include primary pulmonary disease, which can be divided into those that can be treated medically and those requiring surgery. In general, medical conditions in the newborn cause bilateral pulmonary disease, whereas surgical problems are often unilateral and frequently produce contralateral shift of the mediastinum. Cardiac disease is an important cause of respiratory symptomatology in the neonate, for which ultrasound is particularly useful. Extrapulmonary lesions are also important and should be suspected if the chest radiograph is normal or only mildly abnormal in the presence of respiratory distress. Cross-sectional imaging such as computed tomography (CT) is frequently required for the confirmation of diagnosis, further characterization, and preoperative evaluation in the case of surgical lesions (3).

The objective of our study was to assess the value of multiplanar and 3D MDCT images in evaluating respiratory distress in neonates.

2. Patients and methods

2.1. Patients

Within the period between November 2010 and November 2011, 1295 newborn were admitted in neonatal intensive care unit of the Assiut university children hospital with respiratory distress (cyanosis, tachypnea, retraction, grunting, stridor, or feeding difficulties).

Clinical evaluation together with laboratory workup, plain chest X-ray, and/or echocardiography (when it was needed) was done. The final diagnosis was confirmed in 1279 cases as respiratory distress syndrome in 553 cases (42.7%), transient tachypnea of newborn in 435 cases (33.5%), pneumonia & sepsis in 124 cases (9.5%), meconium aspiration syndrome in 59 cases (4.6%), air leak syndromes in 48 cases (3.8%), diaphragmatic hernia in 11 cases (0.8%) and extrapulmonary causes in 49 cases (3.9%). However, in 16 cases (1.2%) plain X-ray findings were suggestive, but it was not conclusive for congenital surgical pulmonary problems. So they were underwent MDCT.

All patients were receiving supportive care in the form of incubator care, oxygen therapy, partial or total parental nutrition, monitoring of vital signs and blood gas analysis, antibacterial therapy and assisted ventilation when indicated. For patients with proved surgical problems, surgical consultation and management were done.

2.2. MDCT examination

Sixteen neonates were scanned using 64-rows multi detectors CT (Aquillion; Toshiba Corporation, Medical System Company, Tokyo, Japan). MDCT was performed with patients in the supine position. We commonly used oral choral hydrate as a sedative drug for those neonates according to practice guidelines for sedation and analgesia published by American society of anesthesia (4). Due to the faster scanning times possible with MDCT scanners, routine sedation is no longer required. In the neonate, recent feeding usually provides tranquillity.

2.2.1. Technical factors

Multidetector CT parameters: using low kilovoltage and tube current appropriately to reduce the radiation dose: 80–100 kV and approximately 60–90 mAs (following an ALARA [as low as reasonably achievable] principle) (5). Other technical parameters are as follows: detector collimation, 64×0.5 mm; beam pitches 0.8 and gantry rotation time 0.5 s and image reconstruction matrices 512×512.

Intravenous contrast material: it is needed to assess the vascular anomalies. Neonates have a smaller than 22-gauge cannula or central venous line in place, the contrast medium was administered by means of manual injection using non-ionic contrast material (300 mgI/ml). The usual recommended contrast material dose is 2 mL per kilogram of patient body weight (up to a dose of 125 mL) (6,7).

Oral contrast medium: it was used in suspected cases of diaphragmatic hernia in order to opacify the bowel. A 60 mL dilute water-soluble iodine based contrast medium was given by nasogastric tube before the examination.

Timing of CT: regarding the postcontrast scan delay, the scan starts at the end of the injection.

Anatomic scan coverage: Scans are usually acquired from the level of thoracic inlet to the level of the diaphragm. In certain situations, however, CT scan coverage must be modified. More inferior extension to the level of the renal artery should be considered in evaluating extralobar sequestration because the anomalous artery in this situation can arise from the descending aorta below the level of the diaphragm (8,9).

Post processing Techniques: After scanning, the axial images were transferred to an independent workstation (Virta, Toshiba) for post processing. Post processing methods: multiplanar reformation or reconstruction (MPR), and 3-Dimensional (3D) imaging including maximum intensity projection (MIP) and volume rendering (VR) images.

2.2.2. Image analysis

Axial, MPR, MIP, and VR images were evaluated independently and retrospectively by two radiologists who reviewed and evaluated all CT studies. The axial images were viewed with standard lung window settings (e.g., width -1,600 to -1,800 H; level, -450 to -550 H) and standard soft-tissue window settings (e.g., width, 400–450 H; level, 40–50 H). Evaluating MPR in coronal, sagittal, and curved planes. The 3D reconstructed images were presented in two formats—one with more opacity to show the vessels and the other with more transparency to show the airway. The axial CT images were interpreted first, followed by the multiplanar images at the same review session. The 3D volume-rendered images were interpreted independently at a later session in depicting the bronchopulmonary and vascular anomalies as following:-

- Pulmonary lesions
  - Symmetry of hemithorax
  - Decrease CT attenuation
  - Increase CT attenuation
Table 1  Pattern of MDCT findings in 16 neonates.

<table>
<thead>
<tr>
<th>Pulmonary Trachea and bronchi</th>
<th>Vascular Associated</th>
<th>No (%)</th>
<th>Radiological diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unilateral opacified hemithorax</strong></td>
<td>5/16 (31.25%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decrease in volume of right lung</td>
<td>Small caliber of right bronchus</td>
<td>Small pulmonary artery</td>
<td>Shift of the mediastinum to the affected right side</td>
</tr>
<tr>
<td>Decrease in volume of left lung</td>
<td>Abrupt tapered left main bronchus</td>
<td>• Aneurysmal dilatation of the main pulmonary artery and ostial stenosis of left pulmonary artery.</td>
<td>• Compensatory hyperinflation of the right lung with transmediastinal shift.</td>
</tr>
<tr>
<td>Decrease in volume of right lung</td>
<td>Abrupt tapered right main bronchus</td>
<td>• Right sided aortic arch with ALSA.</td>
<td>• Opacified left lung</td>
</tr>
<tr>
<td>Total opacified right hemithorax</td>
<td>NA</td>
<td>Ipsilateral mediastinal shift</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Hyper lucent lesions</strong></th>
<th>6/16 (37.5%)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple bilateral air filled cysts communicate with each and with the airway. More than 2 cm in diameter.</td>
<td>NA</td>
<td>Segmental atelectasis of the right upper lobe.</td>
<td>4</td>
</tr>
<tr>
<td>Unilocular Left upper lung air filled cyst about 10 cm</td>
<td>NA</td>
<td>Contralateral mediastinal shift</td>
<td></td>
</tr>
<tr>
<td>Multilocular large air filled cyst occupying almost of the left lower lung lobe that has thick wall.</td>
<td>NA</td>
<td>Alveolar patches of the surrounding lung parenchyma</td>
<td></td>
</tr>
<tr>
<td>Air-filled distension of the upper lobe of the left lung.</td>
<td>NA</td>
<td>Rightward shift of mediastinum.</td>
<td>1</td>
</tr>
<tr>
<td>Presence of both air and fluid in the left pleural space</td>
<td>NA</td>
<td>• Partial collapse of left lung (passive atelectasis)</td>
<td>1</td>
</tr>
<tr>
<td>• Fixed left intercostal tube.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Different alveolar pattern:</strong></th>
<th>5/16 (31.25%)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral patchy area of consolidation</td>
<td>Air bronchogram</td>
<td>4</td>
<td>Pneumonia</td>
</tr>
<tr>
<td>Right upper lobe collapse.</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NA = No Abnormality

- Tracheal and bronchial lesions
  - Abnormal reduced caliber
  - External compression.

- Vascular lesions
  - Pulmonary arteries and veins
  - Aorta

- Any abnormality of pleura, diaphragm and chest cage.

3. Results

Most of the neonates in this study were suffering from respiratory distress due to medical causes in whom clinical evaluation
together with laboratory work, plain chest X-ray, and/or echocardiology when it was needed, were sufficient and they were managed accordingly.

Only 16 neonates were included in whom plain chest X-ray findings were suggestive, and it were not conclusive for congenital surgical pulmonary problems. Their radiologic diagnosis is summarized in Table 1.

Hyperlucent lesions are encountered in 6 neonates including congenital cystic adenomatoid malformation (CCAM), congenital lobar emphysema (CLE) and postoperative hydropneumothorax.

In four neonates presented with CCAM, CT demonstrates multiple air filled cysts that vary greatly in size and shape. 2–8 cm cysts were scattered in both lung lobes mainly the upper lobes in one neonate (Fig. 1). In another neonate, CT depicts a large unilocular air-filled cyst measured 10 cm in maximum diameter occupying almost all of the right lower lobe and the posterior segment of the upper lobe with internal septations and it is associated with mass effect as mediastinal shift to the contralateral side. In the remaining two neonates, a multilocular large air filled cyst occupies almost of the left lower lung lobe that has a thick wall and it is accompanied with alveolar patches involving the surrounding lung parenchyma.

One neonate has CLE; CT depicts the hyperinflation of the left upper lobe with subsequent mass effect upon the adjacent bronchovascular structures (Fig. 2).

One case has left hydro-pneumothorax postoperatively for the repair of the left sided congenital diaphragmatic hernia (Fig. 3).

Unilateral opacified hemithorax was encountered in 5 neonates who have unilateral small sized lungs due to unilateral hypoplastic lung in two cases and unilateral right atelectasis in one case and congenital diaphragmatic hernia in two cases. The first case has a small right lung with mediastinal shift to the affected side and narrow right main bronchus that is clearly seen on MPR and 3D VR images. MPR and 3D images for MDCT angiography revealed hypoplastic right pulmonary artery (2 mm) with absent right pulmonary veins (Fig. 4).

The second case has a small left lung with a narrow left main bronchus and MDCT angiography revealed dilatation of the main pulmonary trunk with osteal stenosis of the left pulmonary artery (2.2 mm) that is smaller than the contralateral one and this was clearly evident on MPR and 3D VR images (Fig. 5).

In another two neonates, opacified right hemithorax with air filled structures occupy the lower lung zone. Instillation

Fig. 1  MDCT images in 15 days male neonate. Axial (a), sagittal (b) and coronal(c) reformatted images demonstrating multiseptated cystic lesion in both lungs mainly in both the upper lobes. The largest was located in the left side with transmediastinal extension (arrowed) consistent with congenital cystic adenomatoid malformation type 1 as clearly evident on 3DVR image (d).
of gastrografine through the Ryle tube revealed opacified intestinal loops herniating into the right hemithorax accompanied with herniating liver with subsequent decrease or no aeration of the right lung clearly evident on MPR and 3D VR images (Fig. 6).

The fifth neonate has a unilateral opacified right hemithorax with ipsilateral mediastinal shift. On follow-up radiographs, reaeration of the right lung occurred and thus it is diagnosed as atelectasis and MDCT helped to exclude anomalies.

Alveolar opacities were seen in five neonates. Four cases have bilateral patchy areas of consolidation and segmental atelectasis. One case has right upper lobe consolidation (Fig. 7).

Regarding the trachea, small caliber of bronchi is encountered in cases of hypoplasia of the lung.

Regarding vascular anomalies, CT angiography in MPR, maximum intensity projection (MIP) and VR images revealed hypoplastic pulmonary artery in one case (Fig. 4) and ostial stenosis of the left pulmonary artery with dilatation of main pulmonary artery in one case. The latter one is associated with a right sided aortic arch with an aberrant left subclavian artery (Fig. 5). Small pulmonary veins are noticed draining the hypoplastic lung.

Common associations are found including mediastinal shift, pneumonic alveolar patches and atelectasis.

4. Discussion

The respiratory distress in neonates may be because of a predominantly medical or surgical pathology or may be a medical condition superimposed on surgical pathology (10).

MDCT may be useful in confirming the presence of the lesion, determining the extent of the lesion, and defining associated abnormalities. Reconstructed data from CT examinations displayed in either 3D or multiplanar formats can be particularly helpful in delineating abnormalities of the bronchi and associated arterial and venous structures (11,12).

In the present prospective study, 16 neonates; whose plain chest radiographs were equivocal; were included and had undergone MDCT examination for further assessment of radiographic abnormalities of reaeration. This is also mentioned by Donnelly and Frush (13) who stated that in cases with
unclear diagnosis, CT often provides diagnostic information about the exact anatomic location of the lesion difficult to determine on chest radiography.

Several acquired and congenital causes of localized lung radiolucencies are seen in neonates, including acute pulmonary interstitial emphysema, localized persistent pulmonary emphysema, congenital cystic adenomatoid malformation (CCAM), and congenital lobar emphysema (CLE). The radiolucent nature of these lesions is also distinct from other congenital lung masses, such as bronchogenic cyst and sequestration that do not typically contain air when encountered during the neonatal period (13). In the present study, six neonates had radiolucent lesions.

In this study, we had only one case of CLE with hyperinflation of the left upper lobe. MDCT images demonstrated a hyperinflated left upper lobe with attenuating and displaced pulmonary vessels and contralateral mediastinal shift that was clearly depicted on reconstructed volume rendering images of the airways. This is consistent with Ozcelik et al. (14) who stated that CLE is usually present during the neonatal period and infancy with respiratory distress, especially when there is marked hyperinflation in the involved lobe and mass effect on the adjacent lung parenchyma or mediastinum with a lobar predilection (left upper lobe > right middle lobe > right upper lobe > lower lobes).

Congenital cystic adenomatoid malformation is resulting from disorganized hamartomatous and adenomatoid proliferation of primary bronchioles, which are in communication with the bronchial tree (15,16). There are three types of CCAM, which have different radiologic appearances, gross pathologic findings, and histologic findings, as described by Stocker et al. (17). The most common subtype is a type 1 CCAM, in which there is at least one dominant cyst that is larger than 2 cm in size. Type 2 CCAM has numerous small cysts of uniform size measuring 1–10 mm in diameter. Type 3 CCAM, the least common, appears solid at imaging; however, at histologic evaluation, it is characterized by numerous microcysts. CCAM demonstrates a variety of imaging appearances based on the type of CCAM and the presence or absence of associated superimposed infection (18). This is consistent with MDCT findings in four cases in the present study as they had type 1 CCAM. Bilateral multilocular air-filled cysts about 2–8 cm occupied most of upper lung lobes in one of them. In another case, a large unilateral air-filled cyst with internal septations occupied most of the right lower lobe and posterior segment of the upper lobe (about 10 cm) causing a mediastinal

**Fig. 3** 25 days male neonate. Contrast enhanced MDCT in axial (a) at upper cuts and sagittal (b) reformate in mediastinal window revealed normal caliber of the pulmonary trunk with symmetrical caliber of main pulmonary arteries and evidence of left pleural effusion with fixed intercostal tube. Coronal reformate (c) image in lung window demonstrates normal shape and caliber of the trachea and both bronchi, presence of air in the pleural space and partial aeration of the left lung as clearly evident on VR images (d). Postoperative hydropneumothorax was the diagnosis.

![Image of CT scans showing normal lung structures and pleural effusion](image-url)
shift to the contralateral side. In the remaining two, unilateral large multilocular thick wall air-filled cysts were seen suggesting the presence of associated infection.

Taylor et al. (19) reported that after congenital diaphragmatic hernia (CDH) repair, a large postoperative pneumothorax is not uncommon and should not be rapidly evacuated because of the increased mobility of the neonatal mediastinum. After the resorption of air surrounding the hypoplastic lung, fluid might accumulate in the pleural space. Follow-up chest imaging after surgical repair might be useful. Cross-sectional imaging can be helpful in cases where the diagnosis is still not clear, and to fully elucidate the spectrum of associated anatomic defects. CT with multiplanar reconstruction is useful to elucidate associated lung masses and bronchopulmonary foregut malformations. The use of intravenous contrast agent and CT arteriography should be considered for depiction of the vascular supply of lung lesions. In the present study, left sided acquired hydropneumothorax secondary to repaired left sided CDH was depicted in one case who was referred to undergo MDCT pulmonary with intravenous contrast administration in order to assess the status of the ipsilateral lung and pulmonary vasculature according to pediatric surgeon’s opinion in our institute.

The differential diagnosis of respiratory distress in the newborn associated with marked opacification of one side of the thorax on radiograph includes atelectasis, congenital diaphragmatic hernia (CDH), congenital cystic adenomatoid malformation (CCAM), pulmonary sequestration, chylothorax, pulmonary hypoplasia, bronchogenic cyst, and a chest tumor (e.g., neuroblastoma, teratoma, fibrosarcoma) (20). Five cases had unilateral opacified hemithorax in the present study.

Pulmonary hypoplasia refers to the presence of a bronchus and rudimentary lung, with a decrease in the number and size of alveoli, airways, and vessels. CT can show asymmetrically decreased lung parenchyma with narrowed airways and fewer branches in the affected hemithorax and herniation with mediastinal shift of the contralateral lung. Clinically, infants with unilateral lobar pulmonary hypoplasia may have variable presentations depending on the extent of lung involvement and comorbidities. Some infants present with severe respiratory distress in the first few hours of life whereas some may be completely asymptomatic. However, most cases of pulmonary hypoplasia are secondary to conditions that limit fetal lung growth. Primary pulmonary hypoplasia is rare. It may be caused by an embryologic defect of the lung or vascular tissues or an in utero vascular accident (21,22). In the present study, unilateral primary hypoplastic lung was encountered in two cases and unilateral secondary hypoplastic lung in two cases.

One of the two cases of primary hypoplastic lung had a small sized right lung with very severe hypoplasia of the
correspondent pulmonary artery. The second case had hypoplasia of the left lung with severe ostial stenosis of the left pulmonary artery that arose from the main pulmonary artery. This second case was also associated with congenital heart disease (ventricular septal defect), aneurysmal dilation of main pulmonary artery and right pulmonary artery and right sided aortic arch with aberrant left subclavian artery (ALSA) with no associated complete vascular ring causing pressure symptoms upon the trachea or esophagus. This is consistent with Türkvatan et al. (23) who reported this anomaly rarely to produce symptoms and is usually an incidental radiological finding and a right arch with an ALSA rarely forms a complete vascular ring.

MDCT barely depicted a small hilum and small pulmonary veins in both primary hypoplastic lung cases. This is consistent with Apostolopoulou et al. (24) and Oguz et al. (25) studies who stated that contrast-enhanced CT of the chest produces an anatomic definition of the pulmonary arteries with consistent quality. An advantage of CT over angiography is that the former allows concomitant evaluation of the bronchial tree and lung parenchyma and the major vascular structures. The complex curving anatomy of the pulmonary artery is well demonstrated by MDCT angiography using multiplanar and volume-rendered images. Thus, MDCT is the preferable method for studying pulmonary aplasia and hypoplasia.

Secondary pulmonary hypoplasia was found in two neonates due to right sided congenital Bochdalek hernia and subsequently reduced size of the right lung. As Ryan (26) who reported secondary pulmonary hypoplasia is an important feature of congenital diaphragmatic hernia and of oligohydramnios, such as the Potter sequence. The difficulty in diagnosing these two cases on radiograph was because the characteristic radiologic appearance of diaphragmatic hernia was unclear. Swischuk (27) and Mandell (28) stated that Bochdalek hernias are more common on the left, while Morgagni hernias occur mostly on the right. If herniation occurs on...
the right side, the bowel and liver or liver alone may fill the right hemithorax represented as dense opacity in the lower right hemithorax. Thus CCAM, particularly when it is located in the lower lobes, can be confused with congenital diaphragmatic hernia. In this situation, CT with coronal and sagittal reconstructions can aid in evaluating the diaphragm thus enabling the radiologist to distinguish CCAM from congenital diaphragmatic hernia (29).

The fifth case had a marked right hemithorax opacification on chest radiography. On follow-up radiographs, neonatal atelectasis was diagnosed and congenital anomalies could be excluded on MDCT.

Five cases in this study were referred to MDCT with pneumonia to exclude underlying congenital anomalies. The most common radiographic manifestation of neonatal pneumonia is a bilateral coarse pattern of perihilar reticular densities which may also involve scattered areas of air space disease. Isolated lobar pneumonia is uncommon in this age group likely related both to the aspirated route of entry as well as to the inability of the neonate to control infection locally (30). In the present study, MDCT depicted segmental atelectasis and alveolar opacities in five neonates. Four cases had bilateral patchy area of consolidation without underlying congenital anomalies. One case had right upper lobar consolidation who was suspected to have tracheo-esophageal fistula (TOF). The presence of TOF could be excluded on reconstructed multiplanar reformate and volume rendering images.

4.1. Limitations of MDCT

The main disadvantage of MDCT is radiation exposure, a factor to be considered particularly in regard to children. Even though, to our knowledge, there are no large-scale epidemiologic studies of the cancer risks associated with CT, conscious effort should be taken to keep the radiation exposure as low as possible during scanning (31,32). Thus we use the lowest possible milliamperage (mA) and kilovoltage (kV). Secondly, we agree with Calder and Owens (33) who stated that automated bolus tracking is problematic in neonates, as drawing a region of interest correctly is difficult in these very small patients.

5. Conclusion

Although a few number of cases were referred to MDCT in our institution but we could state that MDCT was problem solving in complicated cases in whom the simpler tests was inconclusive. We found that MDCT was useful in confirming the presence of the lesion, determining the extent of the lesion, and defining associated abnormalities in all our cases. Reconstructed data from MDCT examinations displayed in either 3D or multiplanar formats can be particularly helpful in delineating the abnormalities of the bronchi and associated arterial and venous structures and was able to differentiate 1ry and 2ry
cases of hypoplasia. Post-processing is essential to fully clarify the relationship of vascular structures to airways. Multiplanar reformatting in axial, coronal and sagittal are an important first step in which the problem of superimposition of densities in the CXR is markedly reduced, and the true distribution of the disease becomes apparent. Maximal intensity projections (MIPS) in thin and thick sections can help to accentuate vascular structures, but may obscure the airways. Volume rendered (VR) images were very useful to demonstrate overall vascular anatomy and detect associated vascular anomalies. The airways were easily reconstructed with VR images which demonstrated the narrowed and congenitally absent bronchi. Lastly, MDCT techniques have revolutionized the imaging of bronchopulmonary, vascular and tracheobronchial anomalies.

References

(18) Berrocal T, Madrid C, Novo S, Gutierrez J, Arjonilla A, Gomez-Leon N. Congenital anomalies of the tracheobronchial tree, lung,


