

TOSHIBA
Leading Innovation >>>

Pediatric Imaging New Approaches in CT

ONE
Aquilion
dynamic volume CT

Case Study Brochure
Arkansas Children's Hospital



TOSHIBA MEDICAL SYSTEMS CORPORATION

<http://www.toshibamedicalsystems.com>

©Toshiba Medical Systems Corporation 2009-2012. All rights reserved.
Design and specifications subject to change without notice.
MCACT0184EAA 2012-06 TME/D

Toshiba Medical Systems Corporation meets internationally recognized standards for Quality Management System ISO 9001, ISO 13485.

Toshiba Medical Systems Corporation Nasu Operations meets the Environmental Management System standard ISO 14001.

Made for Life and Aquilion ONE are trademarks of Toshiba Medical Systems Corporation.

Printed in Japan

ONE
Aquilion

Pediatric Imaging

New Approaches in CT

Introduction

Arkansas Children’s Hospital (ACH) is the only pediatric medical center in Arkansas and the sixth largest in the United States, serving patients from birth to age twenty-one. Our hospital is an affiliate of the University of Arkansas for Medical Sciences (UAMS) and serves as a teaching hospital in pediatrics for UAMS medical students. The Radiology Department offers all imaging modalities and includes three CT scanners, the most recently installed being the Aquilion ONE™ from Toshiba Medical Systems.

The imaging of pediatric patients presents unique challenges as compared to adult patients. Children face greater risks from the effects of ionizing radiation because their developing cells are more sensitive to radiation damage. On the other hand, children have smaller anatomical structures and less fat surrounding their organs, which actually necessitates images with higher signal-to-noise ratios than for adults. Therefore, careful selection of both kV and mA for each child is essential to ensure that images of diagnostic quality are obtained at the lowest possible exposure dose. Automated exposure control is an effective way to achieve this objective and is therefore routinely employed in our CT department.

The second challenge in imaging children is patient motion and respiration. Infants and small children are unable to follow verbal instructions, and older children may also be uncooperative. Traditionally, since a helical scan can last several seconds, it has often been necessary to use some form of sedation to ensure a diagnostically acceptable study. Sedation, however, is not without risks to the patient and should be minimized or eliminated if at all possible.

In March 2009, ACH installed an Aquilion ONE CT system, which has a high-resolution detector capable of covering a range of up to 16 cm in a single gantry rotation. This technology permits a wide variety of pediatric scans to be performed in as little as 350 ms, offering considerable advantages for pediatric patients.

The ability to perform a single-shot scan has significantly reduced the need to administer sedation to our patients. Additionally, volume scanning also provides superior image quality, because entire organs are imaged at the exact same instant in time. Contrast is more evenly distributed in the images and motion artifacts are minimized.

Equally important is the reduction in exposure dose that is possible with the volume scanning technique. Helical acquisition usually requires scanning with an overlapping pitch and overscanning, which may contribute to additional radiation exposure. In fact, for the same level of image noise, we have seen reductions in dose of greater than 50% by employing volume scan mode for some types of examinations.



Dr. Bruce Greenberg, M.D.



Dr. Chetan Shah, M.D.

Table of Contents

Case 1	Hydrocephalus	P4-5
Case 2	One-Rotation Chest CTA	P6-7
Case 3	Arteriovenous Malformation	P8-9
Case 4	Airways Disease	P10-11
Case 5	Suspected Skull Fracture	P12-13
Case 6	Right-Sided Aortic Arch	P14-15
Case 7	Dynamic Volume Lung	P16-17
Case 8	Volume Ankle	P18-19
Case 9	Cystic Fibrosis	P20-21
Case 10	Left Hip Dysplasia	P22-23
Case 11	Craniosynostosis	P24-25
Case 12	Congenital Absence of the Left Lung	P26-27

Reference for Radiation Dose Calculation

Calculation of the effective doses in this brochure is based on the conversion coefficients for pediatric patients given in the following publication:

Influence of patient age on normalized effective doses calculated for CT examinations.

Khursheed A, Hillier MC, Shrimpton PC, Wall BF.
Br J Radiol. 2002 Oct;75(898):819-30.

WARNING: Any reference to x-ray exposure, intravenous contrast dosage, and other medication is intended as a reference guideline only. The guidelines in this document do not substitute for the judgment of a healthcare provider. Each scan requires medical judgment by the healthcare provider about exposing the patient to ionizing radiation. Use the As Low As Reasonably Achievable radiation dose principle to balance factors such as the patient’s condition, size and age; region to be imaged; and diagnostic task.

Hydrocephalus

Patient History

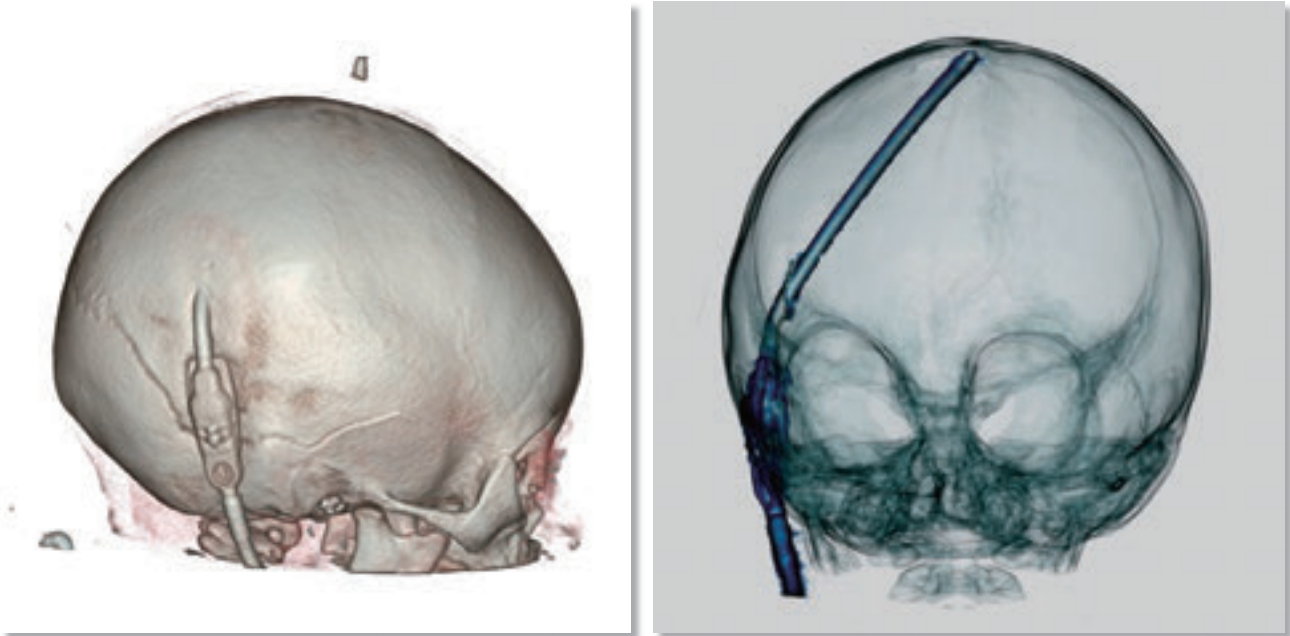
A 5-month-old infant with schizencephaly and hydrocephalus was treated by placement of a ventriculoperitoneal shunt. During follow-up, the patient's mother reported two episodes of possible seizures.

CT imaging was requested to assess the size of the ventricles and the position of the shunt tube as compared to the previous examination.

Scan Protocol

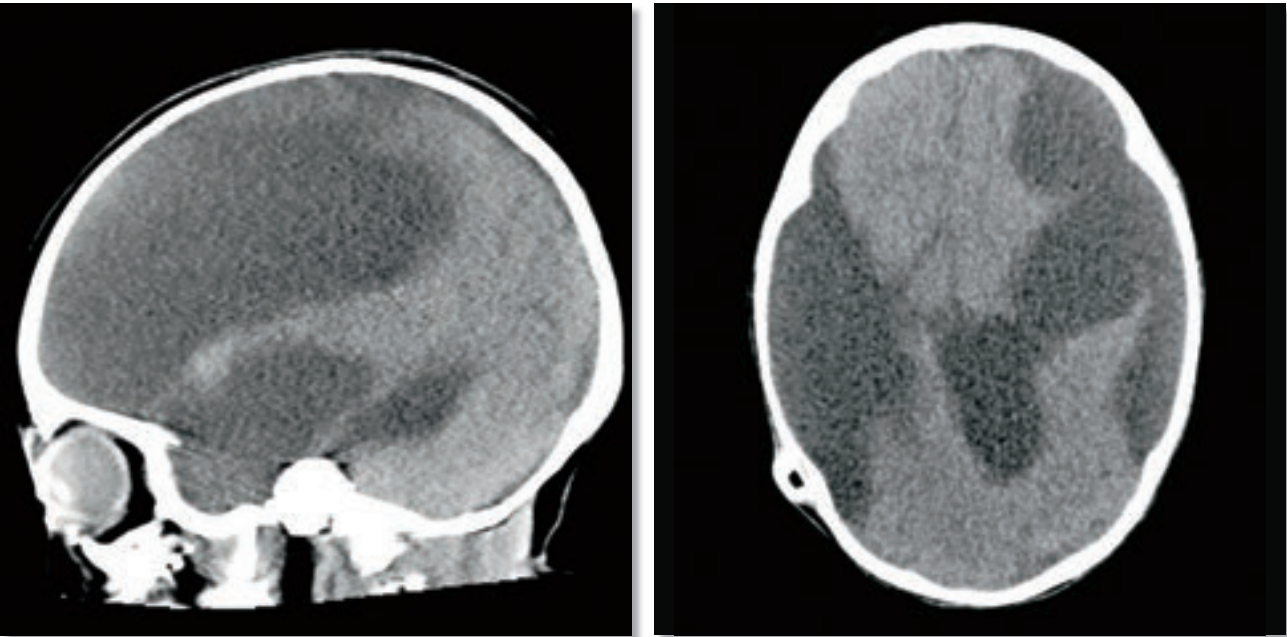
Scan Mode	Volume Scan
Scan Time	1 s
Scan Collimation	0.5 mm
Scan Range	140 mm
Tube Voltage	80 kV
Tube Current	90 mA
Rotation Time	1 s
DLPe	70.6 mGy-cm
Effective Dose	0.40 mSv (k = 0.0056)

A low-dose, single-rotation volume scan acquisition was performed.



The shunt tube enters the right parietal region through a burr hole in the skull. The tip of the shunt lies near the vertex of the skull away from the ventricles, as demonstrated in these 3D images.

Findings



Bilateral schizencephalic clefts are present and ventricular dilatation is noted as compared to the previous examination.

Conclusion

CT confirmed the clinical suspicion of shunt malfunction.

Volume CT scan mode, with its ability to acquire the entire study in a single gantry rotation, is ideally suited to pediatric neurological imaging. The images show consistently superior quality with regard to patient motion and are also obtained at a lower exposure dose because there is no helical overlap.

One-Rotation Chest CTA

Patient History

A 20-month-old boy weighing 13.4 kg presented with a history of coughing, congestion, and wheezing. A contrast-enhanced CT scan of the chest was performed.

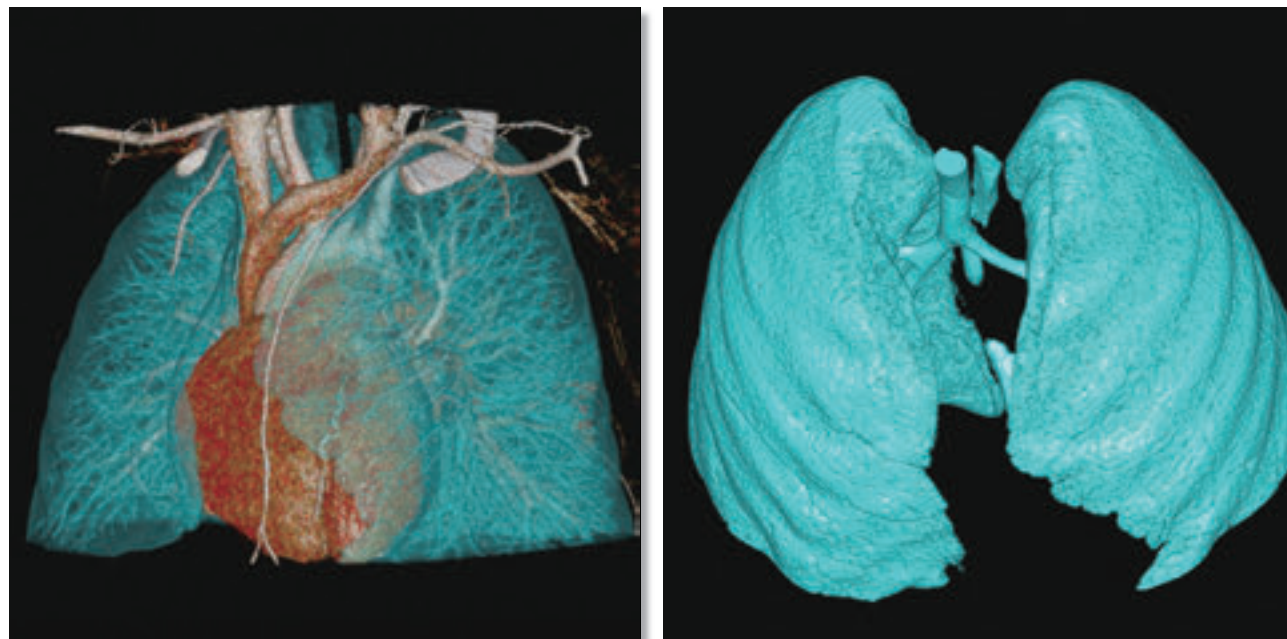
Scan Protocol

Scan Mode	Volume Scan
Scan Time	0.35 s
Scan Collimation	0.5 mm
Scan Range	120 mm
Tube Voltage	80 kV
Tube Current	200 mA
Rotation Time	0.35 s
DLPe	45.2 mGy-cm
Effective Dose	1.38 mSv (k = 0.031)

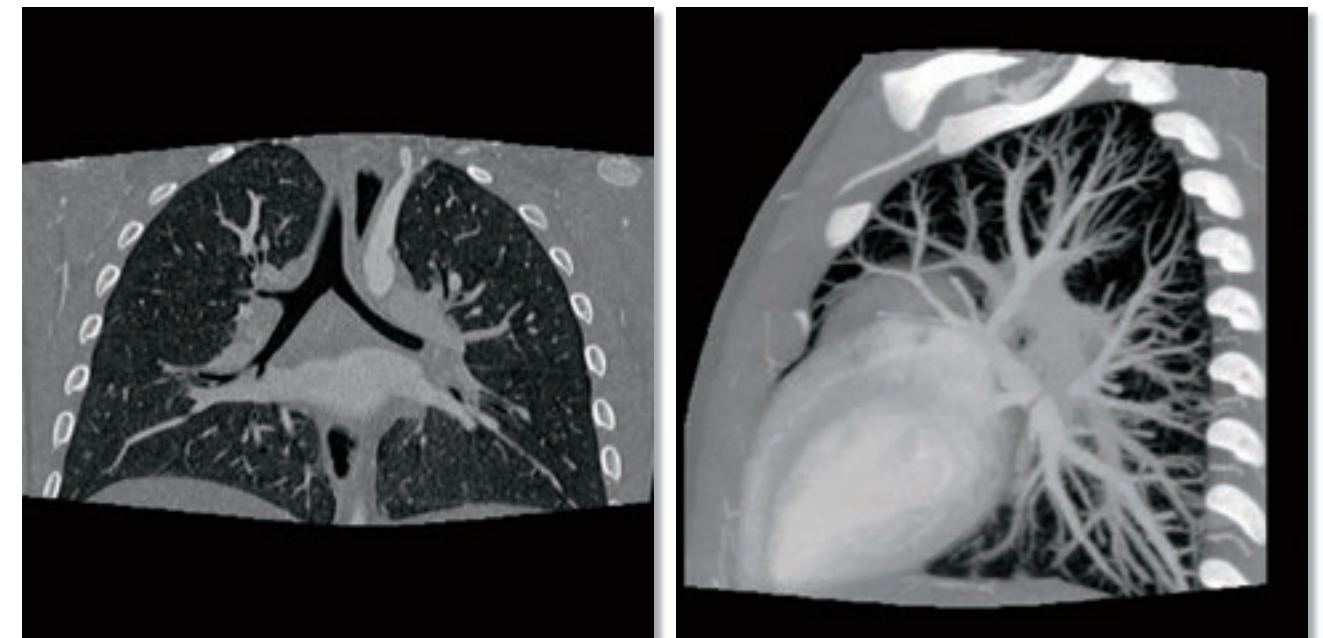
A single-rotation volume scan of the chest was performed during the administration of 9 mL of iodinated contrast medium.

The volumetric scan was visually triggered at full inspiration.

Findings



The trachea and bronchi are normal. No anomalous vessels are present to cause tracheal compression.



Detailed images of the lungs show excellent uniformity because the entire scan was performed in the exact same phase of respiration and contrast enhancement.

A few right hilar lymph nodes measuring up to 1 cm in size are seen. Areas of basilar atelectasis are also noted.

Conclusion

This examination showed no vascular ring or anomalous vessel causing tracheal compression. Some basilar atelectasis was observed.

This scan of the entire chest was acquired in just 350 ms, showing perfect temporal and contrast uniformity. The scan was easily triggered visually at peak inspiration, much like a portable chest film is obtained in an intensive care setting. One-shot volume scan technology provides superior image quality with a dramatic reduction in sedation requirements in pediatric CT studies as compared to multidetector technology.

Arteriovenous Malformation

Patient History

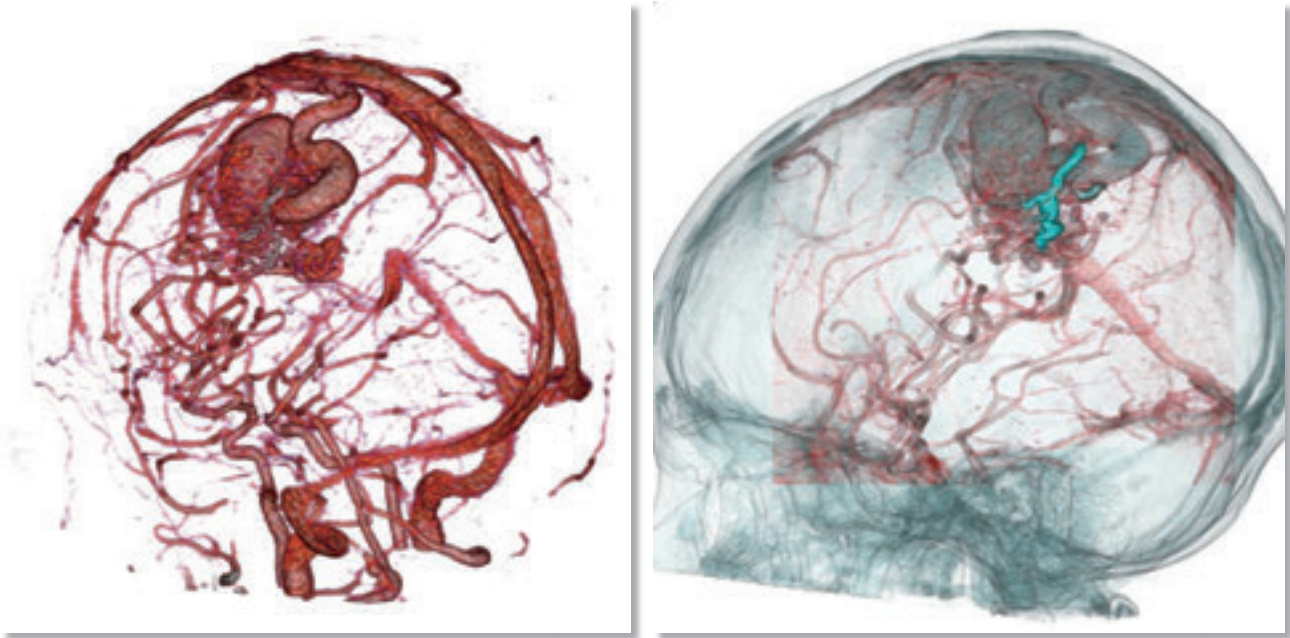
A 7-year-old boy underwent interventional repair of an intracranial arteriovenous malformation (AVM) by coil embolization.

4D digital subtraction angiography (4D DSA) by dynamic volume CT was requested.

Scan Protocol

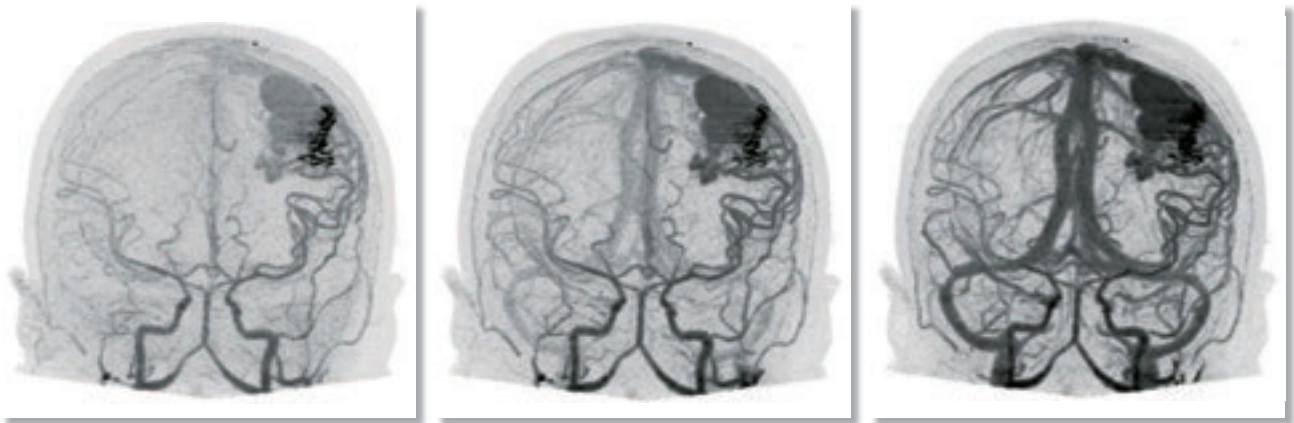
Scan Mode	Dynamic Volume Scan
Scan Collimation	0.5 mm
Scan Range	140 mm
Tube Voltage	80 kV
Tube Current	150 mA
Rotation Time	0.75 s
DLPe	795 mGy.cm
Effective Dose	2.82 mSv (k = 0.0035)

Scanning was performed in intermittent dynamic volume scan mode, with acquisition of one volume every 2 seconds over a total of 14 seconds. The scan timing was synchronized to observe the arrival of contrast medium and the venous drainage.



The AVM has prominent draining veins exhibiting aneurysmal dilatation.

Findings



The blood flow dynamics can be observed in DSA images as shown above. The AVM is predominately supplied via a network of branches from the left middle cerebral artery.

Conclusion

Blood flow dynamics are clearly depicted in 4D DSA images generated automatically at the scan console. Manipulating the 4D volume in real time permits detailed assessment of AVM morphology. This study demonstrated the feeder arteries to the AVM as well as the draining veins.

Airways Disease

Patient History

A 4-year, 8-month-old boy presented to the outpatient clinic with a persistent productive cough, fever, and a history of recurrent lung and upper airway infections.

A contrast chest CT was requested.

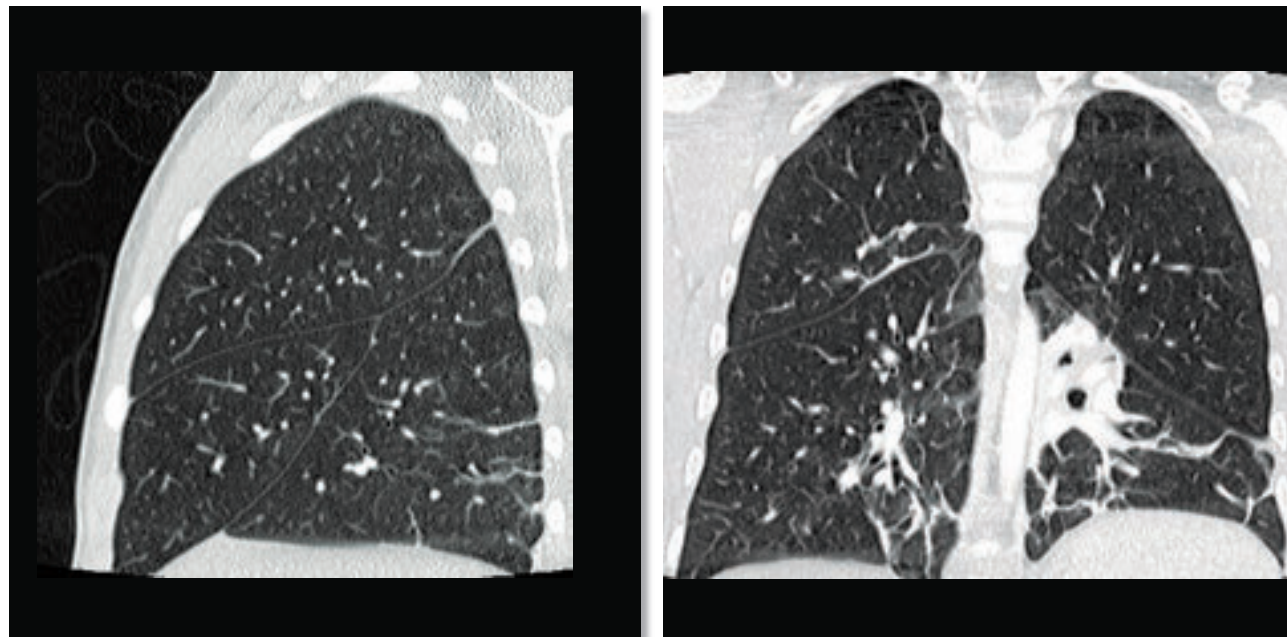
Scan Protocol

Scan Mode	Volume Scan
Scan Time	0.35 s
Scan Collimation	0.5 mm
Scan Range	160 mm
Tube Voltage	100 kV
Tube Current	140 mA
Rotation Time	0.35 s
DLPe	84.2 mGy-cm
Effective Dose	1.93 mSv (k = 0.023)

A volume scan of the chest covering 16 cm was performed during intravenous contrast injection.

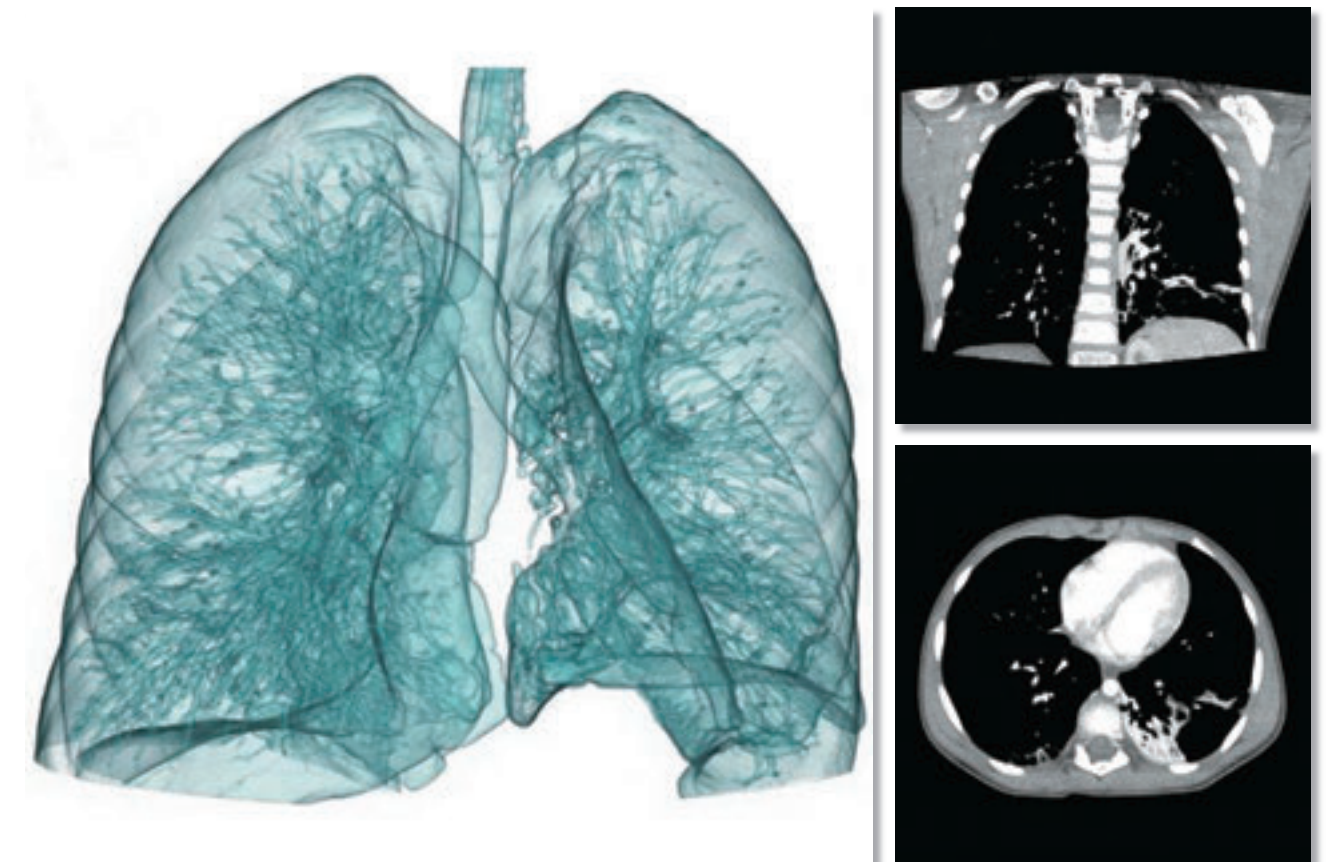
This examination was performed in 0.35 second, eliminating the need for sedation.

Findings



Mild subsegmental atelectasis is seen in the right upper lobe adjacent to the major fissure. Patchy atelectasis is observed in the right lower lobe.

Consolidation is seen in the superior segment of the left lower lobe extending into the medial basal segment.



Mild bronchial dilatation is seen in the superior segment of the left lower lobe. This is most likely related to the overlying pneumonia.

Conclusion

The ideal CT scanner for children should have a number of features. The scanner must be fast, reducing the need for sedation and minimizing motion artifacts. High spatial resolution is essential due to the small size of the target structures. Finally, the fact that children have an increased sensitivity to radiation means that low-dose techniques are critical for widespread acceptance.

Aquilion ONE is the only CT system on the market today that supports single-rotation volume imaging, providing high-resolution images with low-dose scanning.

Suspected Skull Fracture

Patient History

A 5-month-old patient was referred from an outside facility for suspected child abuse. The previous CT scan performed outside indicated an occipital skull fracture in axial images. A skull X-ray showed similar findings. No previous injuries were reported, and there were no prior fractures or bruising elsewhere on the patient's body.

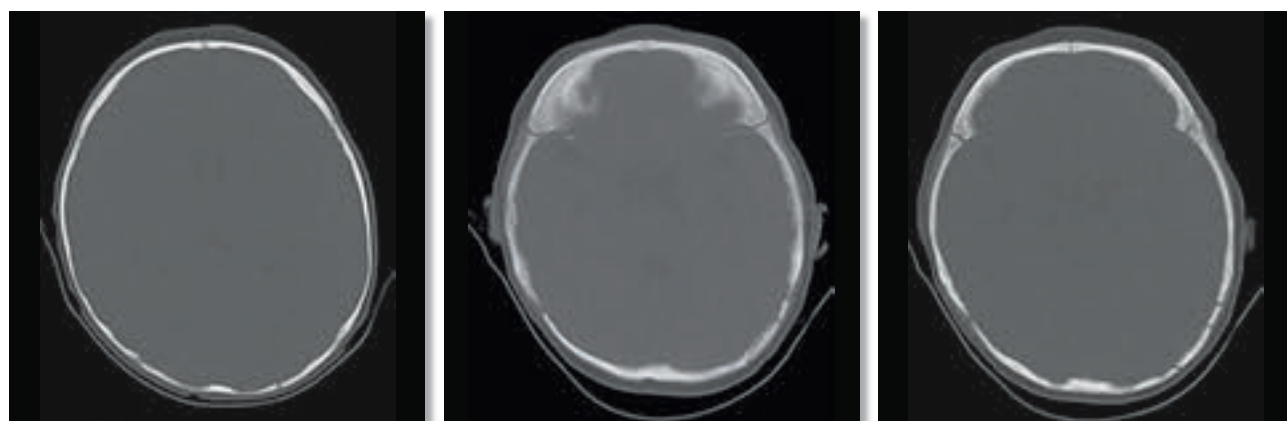
A repeat head CT scan was requested.

Scan Protocol

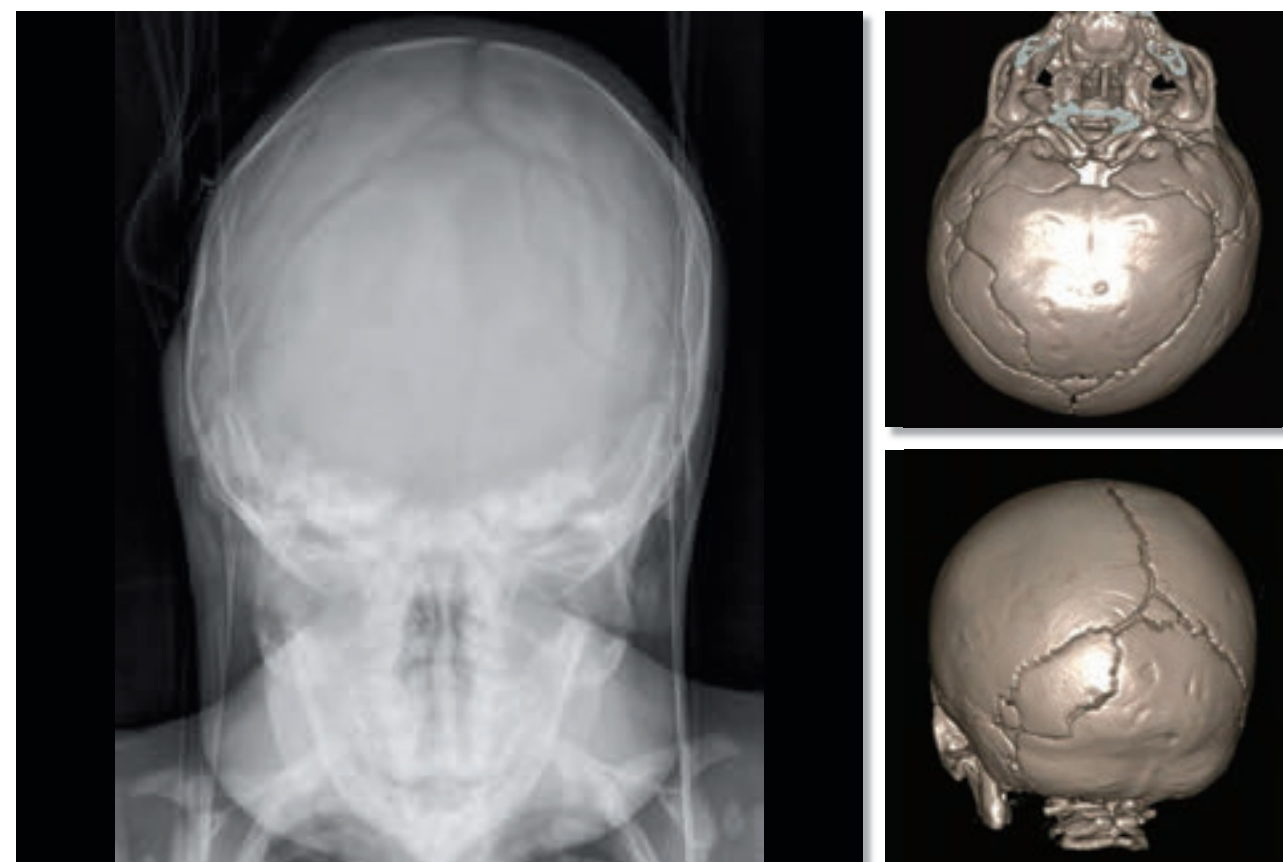
Scan Mode	Volume Scan
Scan Time	1 s
Scan Collimation	0.5 mm
Scan Range	140 mm
Tube Voltage	100 kV
Tube Current	80 mA
Rotation Time	1 s
DLPe	117.30 mGy·cm
Effective Dose	0.66 mSv (k = 0.0056)

A single-rotation volume scan acquisition was performed to cover the patient's head. This scan was completed in 1 second.

Findings



The axial images show linear lucencies in the left occipital bone that are highly suggestive of an occipital skull fracture. This appearance is consistent with the findings of the previous imaging studies.



A skull X-ray shows a suspected fracture line in the left occipital bone corresponding to the findings of axial CT.

The 3D volume-rendered images generated from the volume scan data were very important in this case because they clearly demonstrate that the previously reported fracture is actually an accessory occipital suture.

Conclusion

This patient was demonstrated to have an accessory occipital suture, which is a normal variant.

The advantages of 3D volumetric imaging were essential for reaching the correct diagnosis in this case, diffusing a potentially tragic situation for the patient's family.

In addition, the volumetric scan technique permitted images to be acquired at a 20% to 30% lower exposure dose as compared to helical acquisition, while providing superior spatial resolution.

The 0.5-mm acquisition technique allows excellent multiplanar and 3D images to be generated routinely for all patients.

Right-Sided Aortic Arch

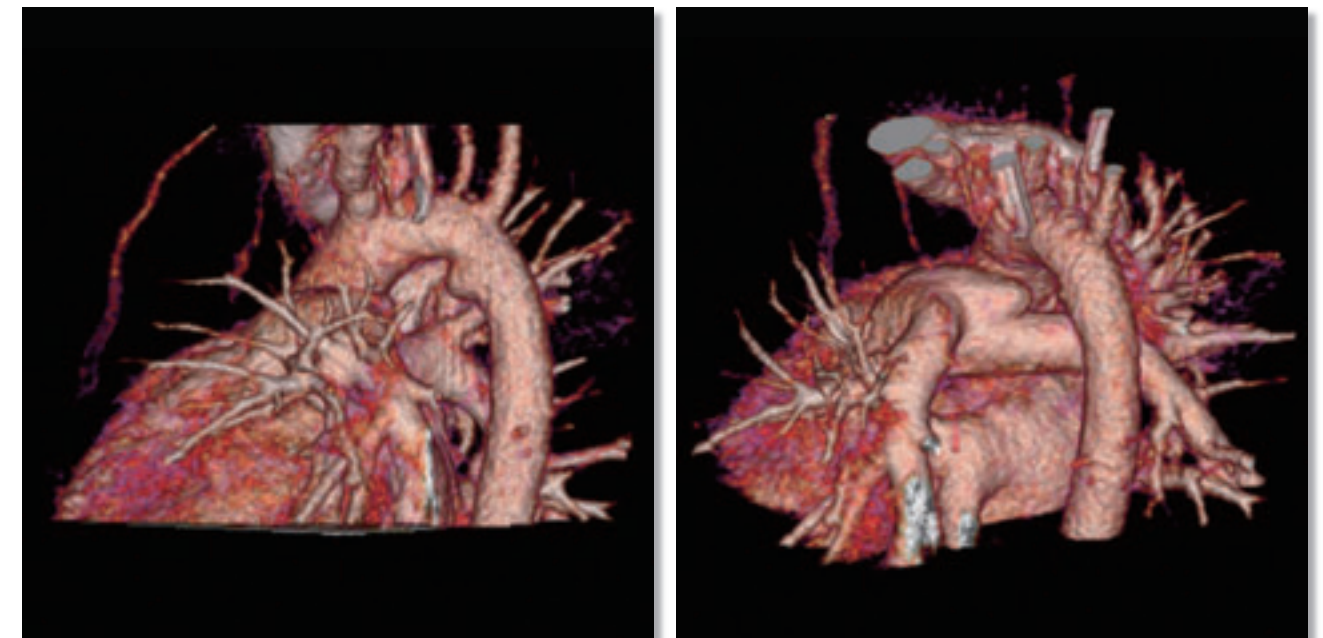
Patient History

A 21-day-old male infant in respiratory distress was sent for a CT chest scan to evaluate the possibility of vascular rings causing tracheal compression. The patient was also suspected to have a right-sided aortic arch.

Scan Protocol

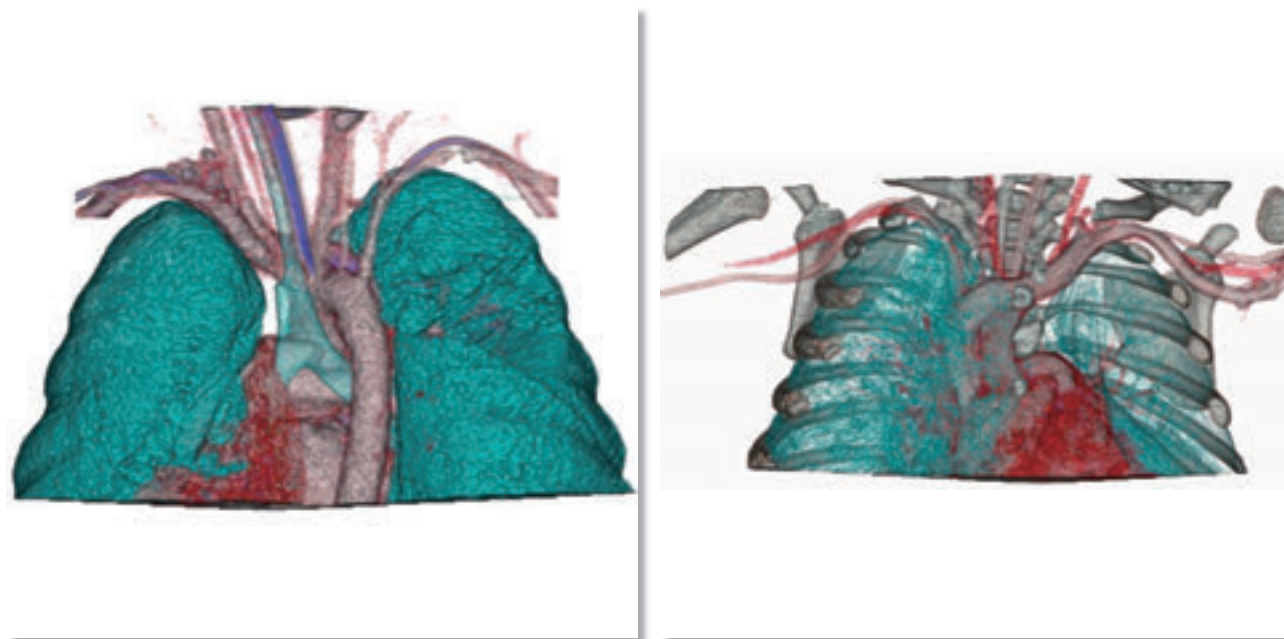
Scan Mode	Volume Scan
Scan Time	0.35 s
Scan Collimation	0.5 mm
Scan Range	160 mm
Tube Voltage	80 kV
Tube Current	90 mA
Rotation Time	0.35 s
DLPe	11.3 mGy-cm
Effective Dose	0.41 mSv (k = 0.037)

A single-volume scan acquisition of the chest was performed during the intravenous injection of 6 mL of contrast medium.



A ductus bump can be seen in the proximal descending aorta. A diverticulum projects from the pulmonary artery, but no patent ductus arteriosus is present.

Findings



These 3D images demonstrate a right-sided superior vena cava and a right-sided aortic arch with mirror-image branching.

No vascular ring or sling is observed. Note the endotracheal tube shown in dark blue.

Conclusion

This patient has a right-sided aortic arch with mirror-image branching of the great vessels. Tracheal compression from a vascular ring or sling was ruled out.

The diagnosis of congenital cardiovascular anomalies in small children has traditionally required careful study of the data. Volumetric scanning improves the image quality and interpretability of these types of scans, resulting in faster and more accurate diagnosis. This improvement is directly related to the ability to capture the entire anatomy at the exact same instant in time, which eliminates any discontinuity of the organs due to cardiac or respiratory movement, as can occur in helical scanning.

Dynamic Volume Lung

Patient History

An 8-month, 19-day-old male infant weighing just 6.4 kg underwent surgery for gastroschisis, a congenital abdominal wall defect in which the intestines develop outside the fetal abdomen. The patient also had respiratory distress syndrome and developed streptococcal pneumonia and subsequent bronchopulmonary dysplasia.

A dynamic volume chest scan was requested to assess lung function and morphology.

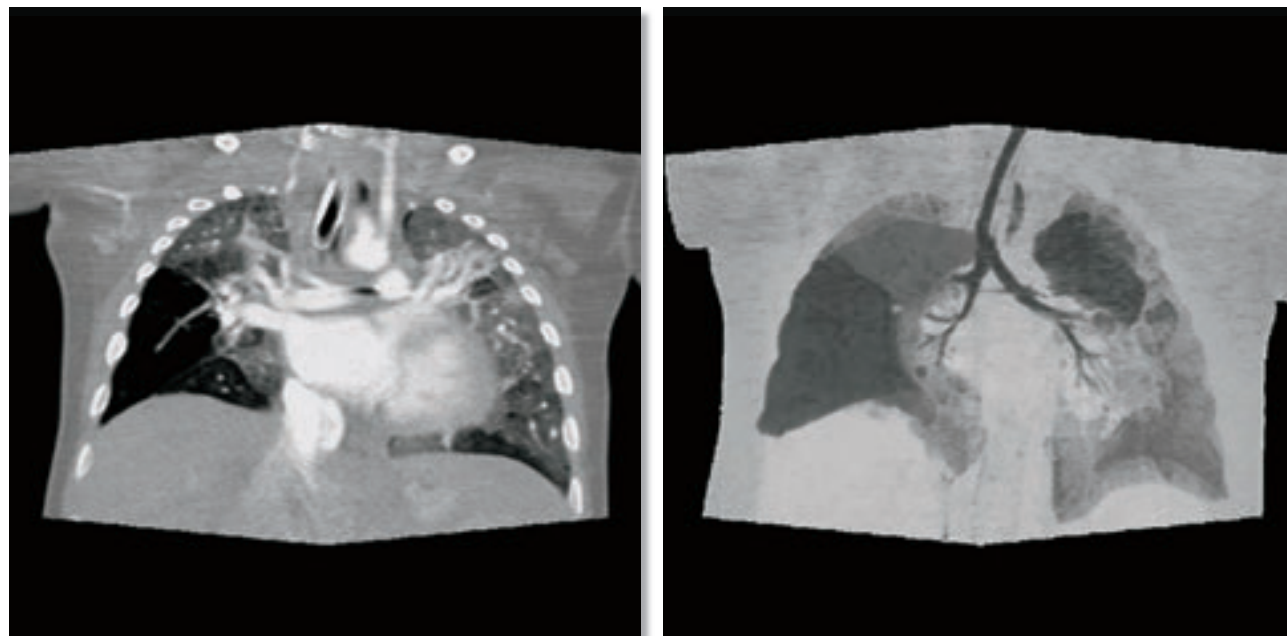
Scan Protocol

Scan Mode	Dynamic Volume Scan
Scan Time	1.4 s
Scan Collimation	0.5 mm
Scan Range	120 mm
Tube Voltage	80 kV
Tube Current	60 mA
Rotation Time	0.35 s
DLPe	53.6 mGy·cm
Effective Dose	1.48 mSv (k = 0.03)

A low-dose dynamic volume chest scan was performed in a total time of 1.4 seconds during spontaneous breathing. Volumes were reconstructed every 0.15 second.

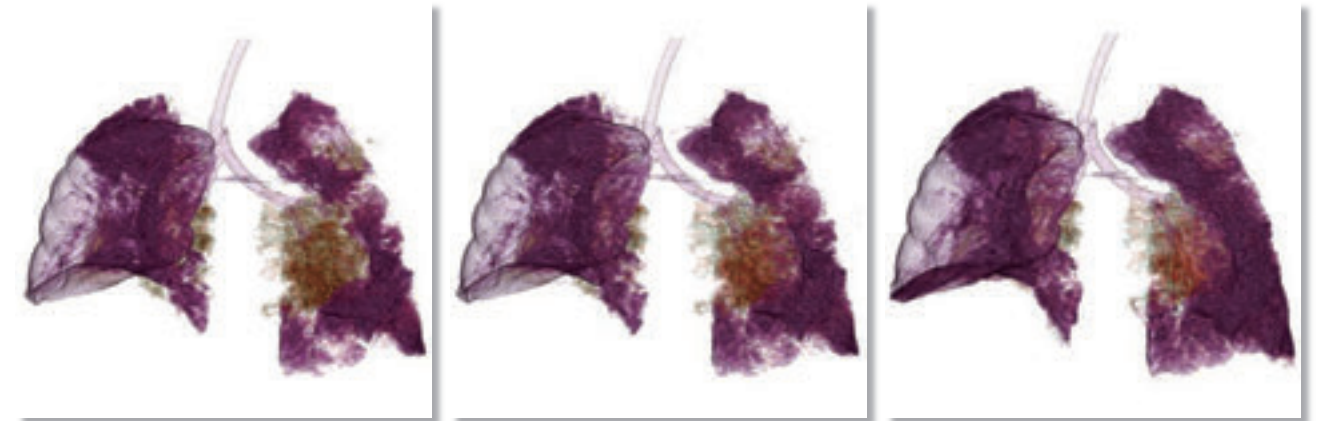
In this study, 19 mL of intravenous contrast medium was administered via a central femoral venous line at a rate of 1 mL/s.

Findings



Dependent atelectasis in the posterior portions of both lungs is observed. Air trapping is present in the middle lobe and posterior segment of the left upper lobe, which is best seen in the MinIP image.

3DVR Dynamic lung views



Dynamic MinIP views



Dynamic imaging makes it possible to create cine loops, allowing the evaluation of regional pulmonary motion and the confirmation of lobar and segmental atelectasis.

Conclusion

This patient has airspace disease with middle lobe and posterior segment left upper lobe air trapping that was confirmed on review of dynamic imaging during respiration. These findings suggest obstruction of the middle lobe and posterior left upper lobe segmental bronchi.

Volume Ankle

Patient History

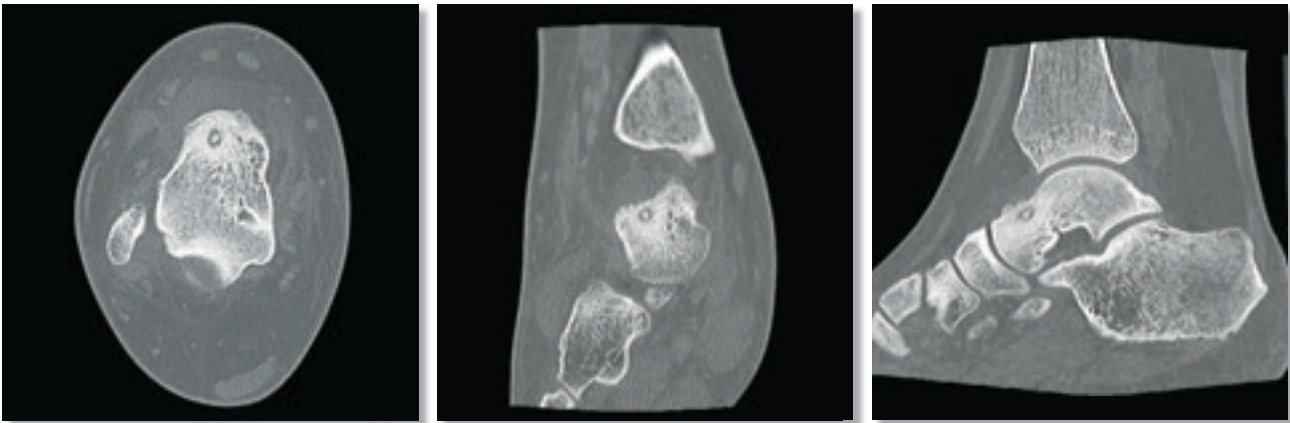
A 13-year-old patient presented to the emergency department complaining of right ankle pain. A previous history of aplastic anemia was noted.

A CT scan of the ankle and foot was requested.

Scan Protocol

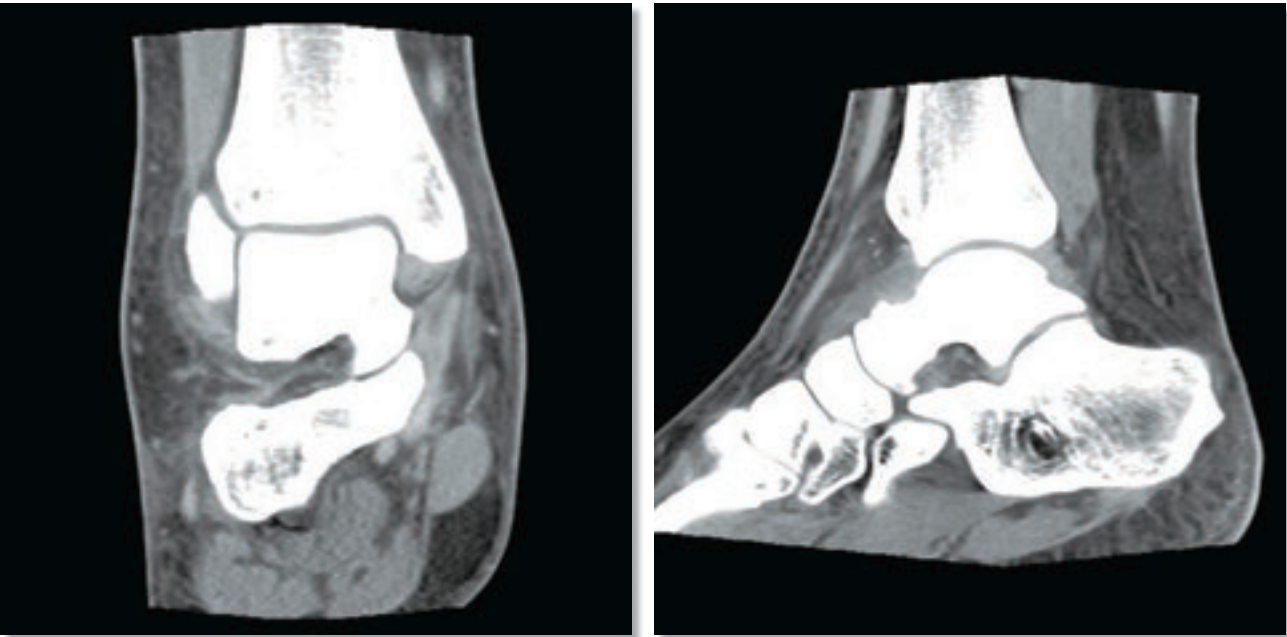
Scan Mode	Volume Scan
Scan Time	0.5 s
Scan Collimation	0.5 mm
Scan Range	120 mm
Tube Voltage	120 kV
Tube Current	150 mA
Rotation Time	0.5 s
DLPe	152.8 mGy-cm
Effective Dose	0.05 mSv (k = 0.00031)

A single-rotation 0.5-mm volume scan was performed of the patient’s ankle/foot. MPR images were automatically generated in the examination protocol.



High-resolution bone reconstruction images clearly demonstrate a focal low-attenuation lesion in the anterior talus with a sclerotic nidus. Sclerosis of the adjacent bone trabeculae is noted.

Findings



A small effusion in the ankle joint is clearly visualized in soft tissue images. In addition, there is an increased soft tissue density overlying the talus, which could be indicative of underlying inflammatory changes.

Conclusion

This bone lesion exhibits the characteristics of an osteoid osteoma. The joint effusion and surrounding sclerosis are associated with the osteoid osteoma. CT-guided radiofrequency ablation was selected for treatment in this case.

Multiplanar imaging with high-resolution volume CT provides excellent depiction of the soft tissues and fine bony structures in imaging of the extremities. Generating such views as part of the scan protocol speeds workflow and ensures consistency for all examinations.

Cystic Fibrosis

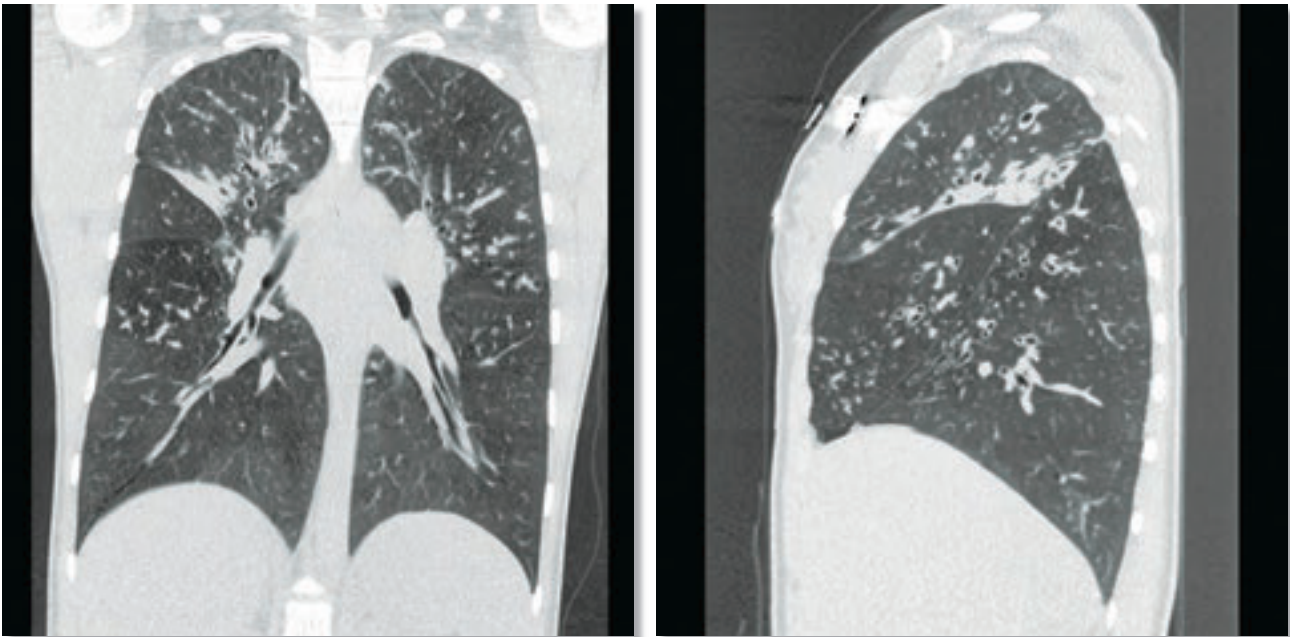
Patient History

A 14-year-old girl with known cystic fibrosis presented to our hospital in acute respiratory distress. A high-resolution chest CT scan was requested to assess the progression of her disease due to the worsening of her condition.

Scan Protocol

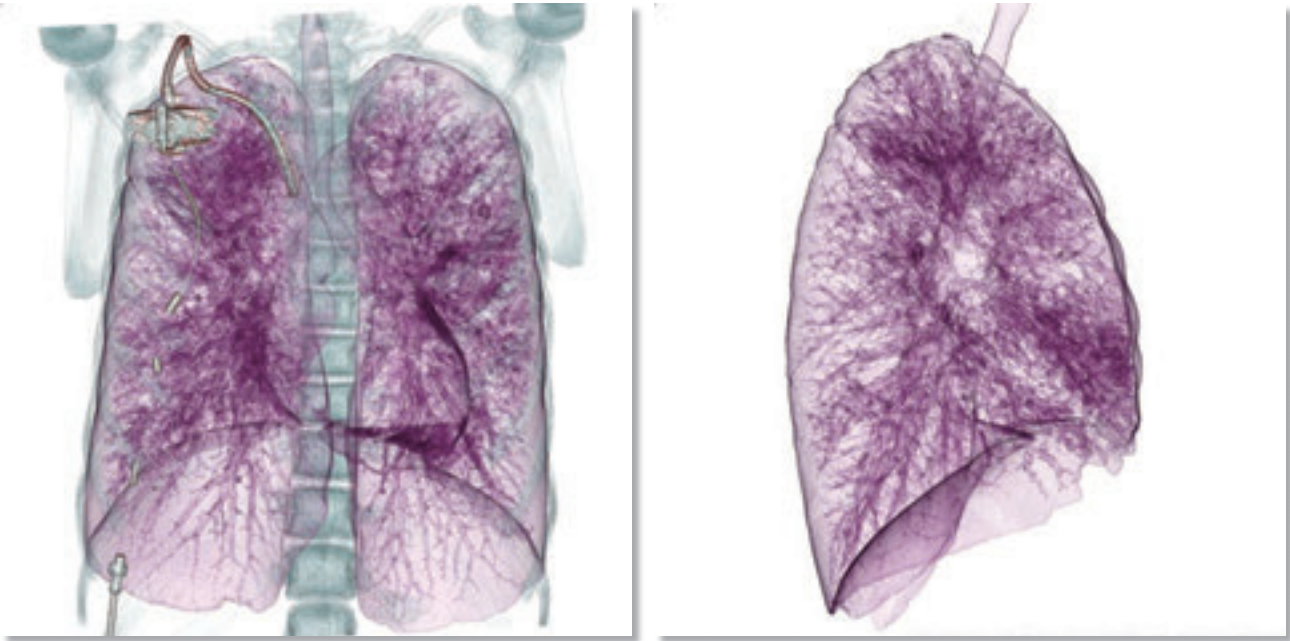
Scan Mode	Wide-Volume Scan
Scan Collimation	0.5 mm
Scan Range	305 mm
Tube Voltage	80 kV
Tube Current	Modulated
Rotation Time	0.5 s
DLPe	108 mGy·cm
Effective Dose	2.13 mSv (k = 0.02)

A wide-volume scan technique was used to scan the patient's chest. Three volume scans were stitched together to create 3D images of the entire chest. This scan mode retains the advantages of volume scanning while permitting coverage of larger areas of anatomy.



Diffuse bronchiectasis is demonstrated in both lungs, as shown in these MPR images. Several peripheral densities are consistent with mucous plugs.

Findings



An infusaport is shown entering the superior vena cava. Multiple areas of atelectasis are observed, particularly in the right upper lobe and right middle lobe.

Conclusion

Bronchiectasis is a common presentation in patients with advanced cystic fibrosis. The findings of this examination show considerable progression of disease as compared to previous images. Traditionally, high-resolution chest CT is performed with thin-slice axial images acquired at 10-mm intervals throughout the lung. With the widespread adoption of multidetector CT systems, such examinations are often performed with a thin-slice helical acquisition, which permits the generation of clinically valuable multiplanar images. In a wide-volume acquisition, two or more volumetric scans are acquired and combined into a single high-resolution volume, which also permits MPR imaging, but at a lower exposure dose than in helical scanning.

Left Hip Dysplasia

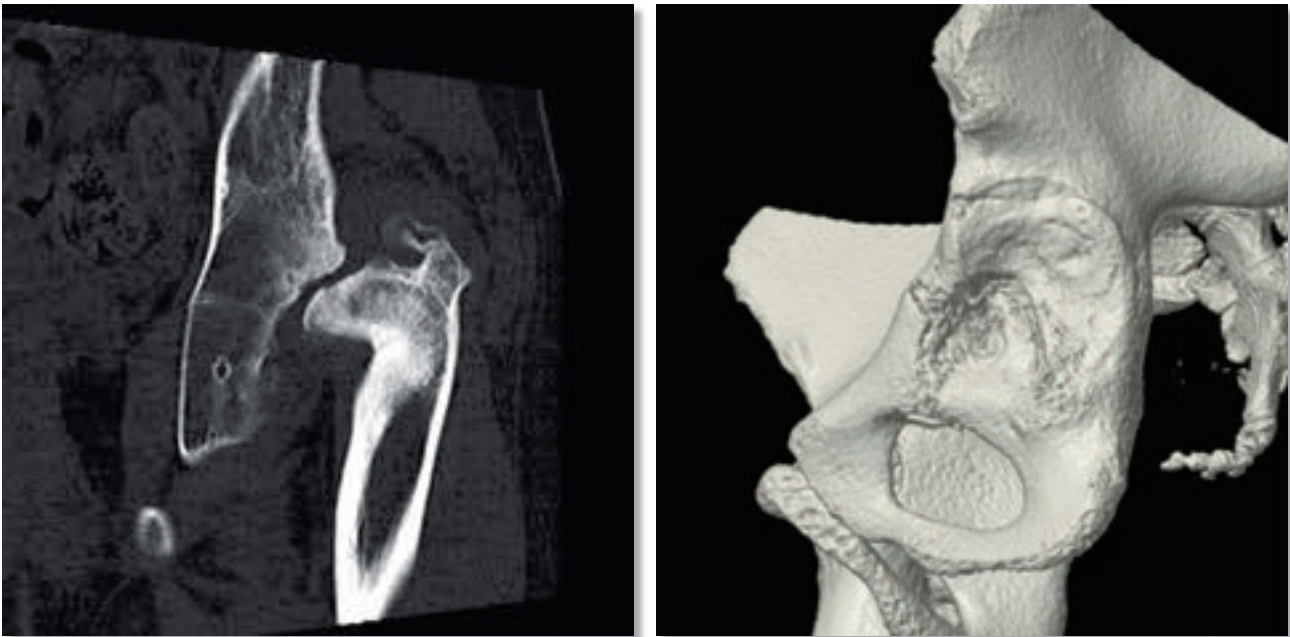
Patient History

A 10-year-old girl with known left hip dysplasia was referred for a follow-up CT examination.

Scan Protocol

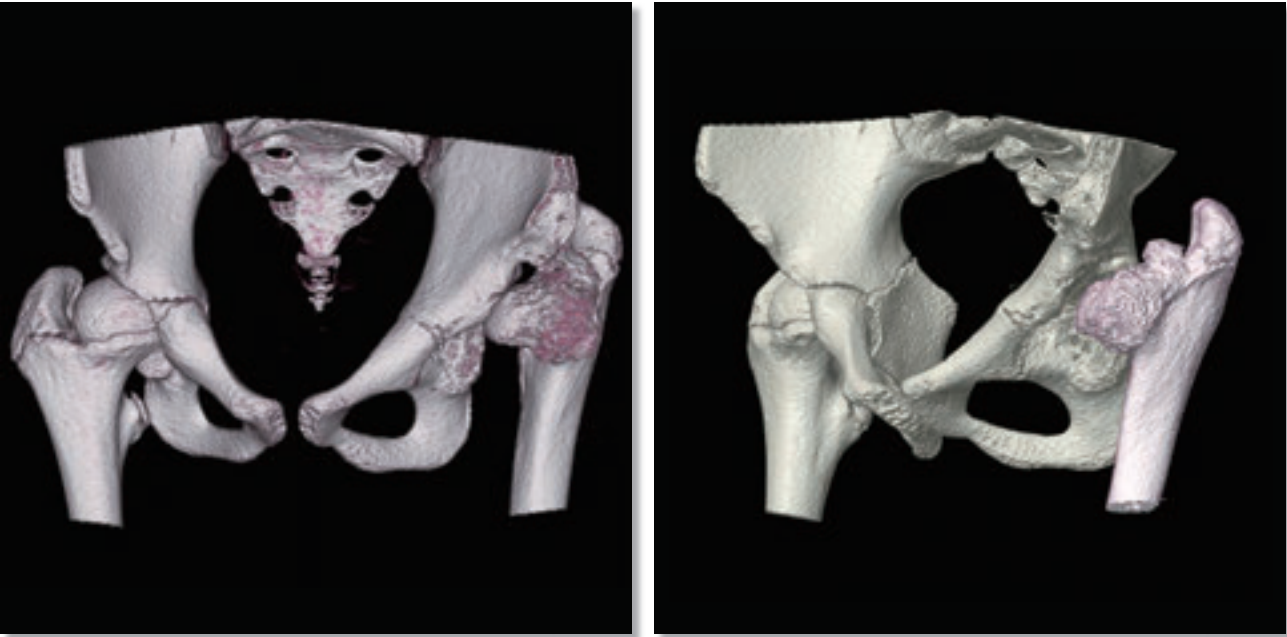
Scan Mode	Volume
Scan Time	0.5 s
Scan Collimation	0.5 mm
Scan Range	160 mm
Tube Voltage	100 kV
Tube Current	120 mA
Rotation Time	0.5 s
DLPe	44.8 mGy·cm
Effective Dose	0.81 mSv (k = 0.02)

A low-dose volume scan of the pelvis was performed in a single 0.5 s rotation.



The femur is displaced superiorly, creating a pseudo-acetabulum above the true acetabulum. Some cystic changes are demonstrated in the left femoral head.

Findings



Severe deformity and dysplasia of the left proximal femur is demonstrated in these 3D volume-rendered images. An associated coxa vara deformity is also noted.

Conclusion

This patient has severe bone dysplasia of the left proximal femur, with superior displacement of the femur creating a pseudo-acetabulum.

Volumetric scanning permitted this study to be performed in just half a second and with an effective dose of only 0.8 mSv.

Craniosynostosis

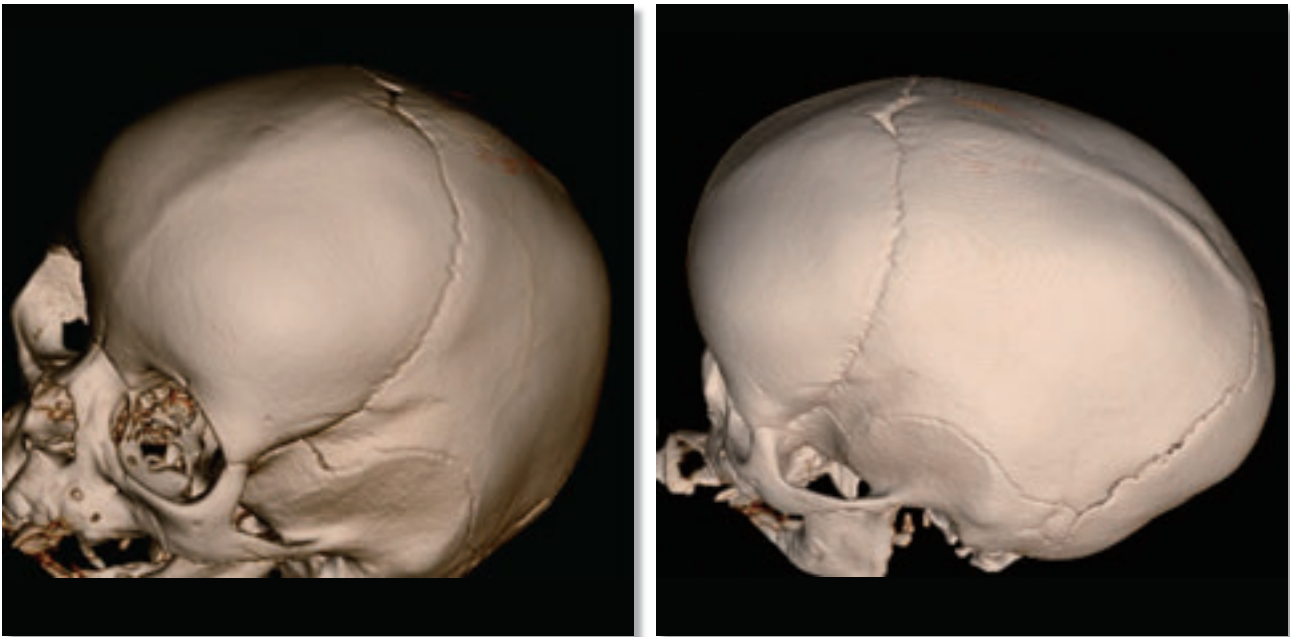
Patient History

A 9-month-old infant with scaphocephalic skull shape was referred for CT scan of the head.

Scan Protocol

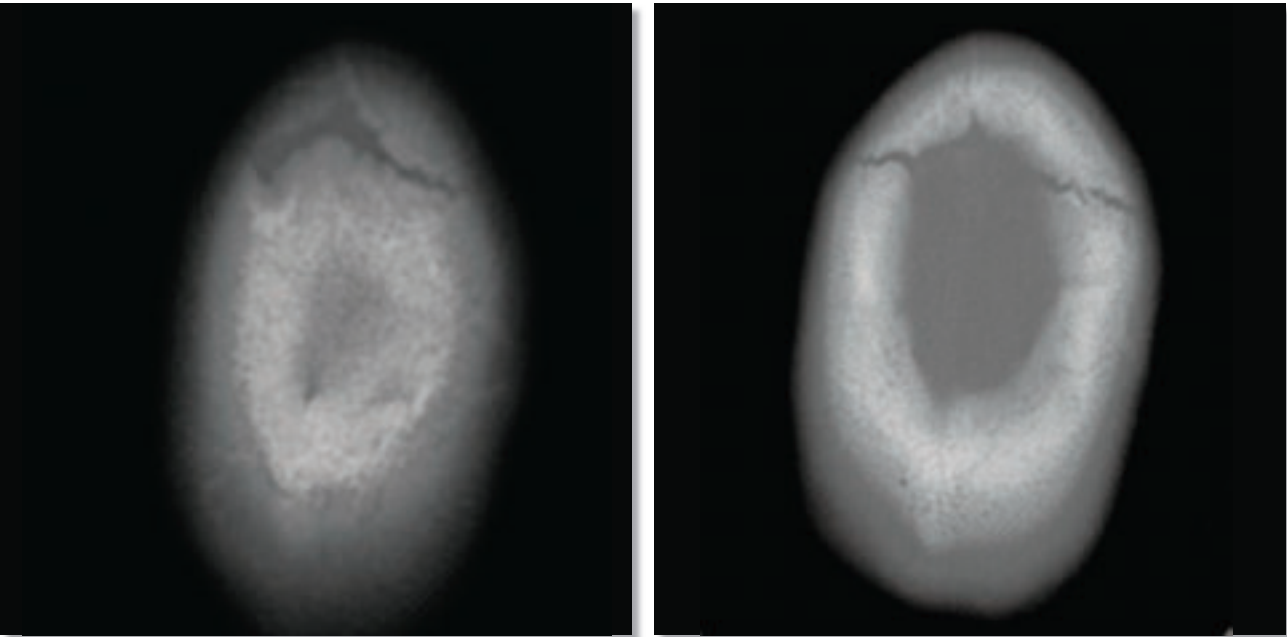
Scan Mode	Volume
Scan Time	1 s
Scan Collimation	0.5 mm
Scan Range	160 mm
Tube Voltage	100 kV
Tube Current	150 mA
Rotation Time	1 s
DLPe	257.9 mGy·cm
Effective Dose	1.36 mSv (k = 0.0053)

A low-dose, single-rotation volume scan CT acquisition of the entire head was performed in just 1 second.



3D volume-rendered images show sagittal synostosis with ridging of the sagittal suture. In addition, these images show metopic synostosis with ridging that is not appreciated in axial images.

Findings



Axial images demonstrate that the sagittal suture cannot be visualized. However, the fused sagittal suture and ridging are not well appreciated.

Conclusion

The CT scan confirmed the clinical suspicion of cranial synostosis.

The volume CT scan mode with the ability to generate 3D volume-rendered images can show details of skull anomalies that are useful to surgeons.

Congenital Absence of the Left Lung

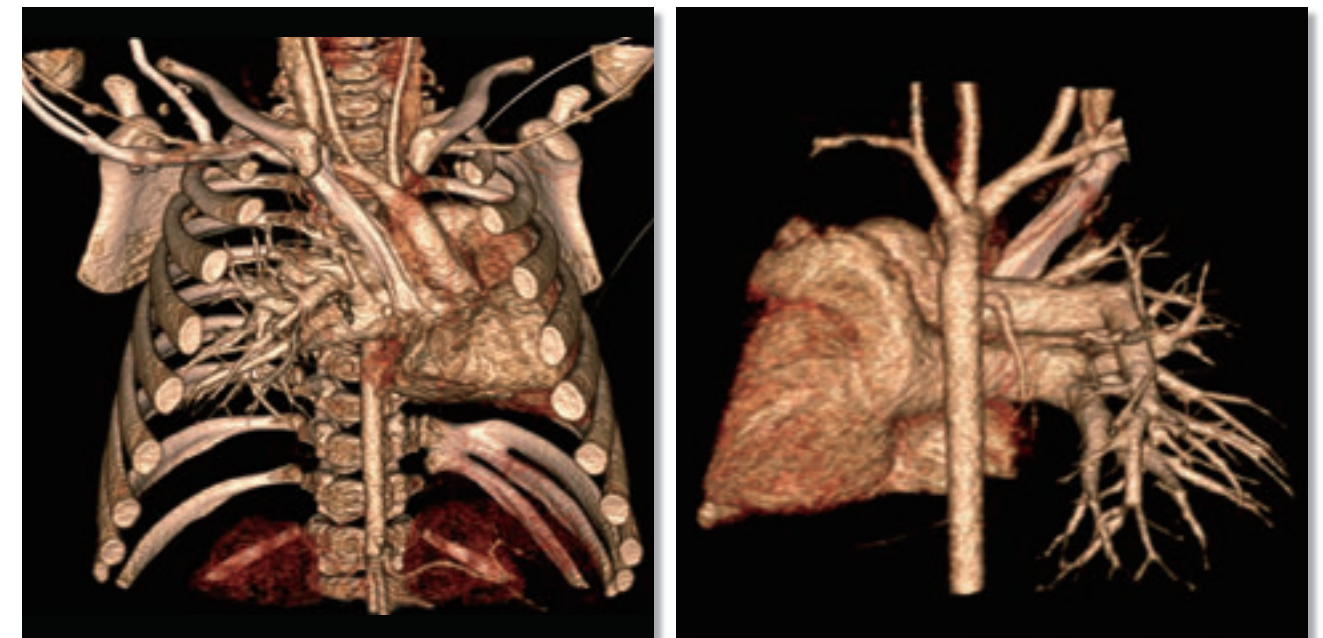
Patient History

A 3-month-old girl presented in respiratory distress. A CT scan was requested to evaluate the possibility of congenital absence of the left lung.

Scan Protocol

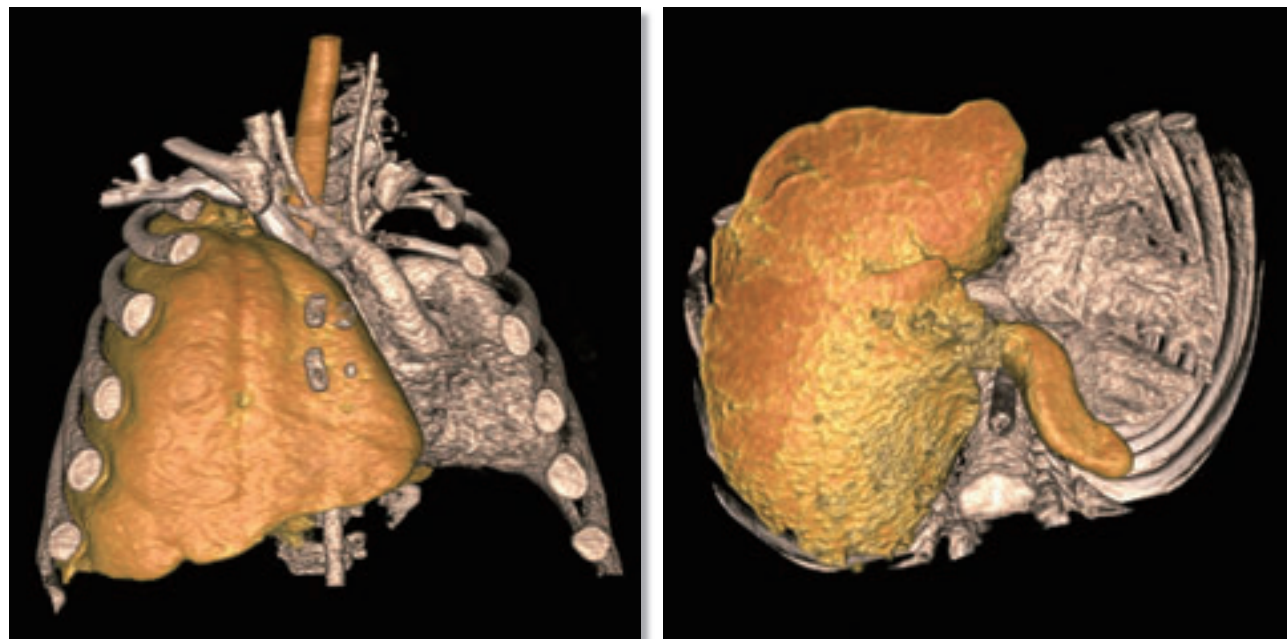
Scan Mode	Volume
Scan Time	0.35 s
Scan Collimation	0.5 mm
Scan Range	140 mm
Tube Voltage	80 kV
Tube Current	110 mA
Rotation Time	0.35 s
DLPe	30.1 mGy-cm
Effective Dose	1.2 mSv (k = 0.039)

A low-dose volume scan CT acquisition of the chest was performed in a single 0.35 s rotation.



The heart is seen to be rotated into the left hemithorax. There is a solitary pulmonary circulatory system to the right lung.

Findings



These 3D images demonstrate complete absence of the left lung. The right lung is hyperexpanded and a portion of the lower lobe has herniated across the midline and into the left chest cavity.

Conclusion

The diagnosis of left lung aplasia was confirmed and excellent depiction of the cardiovascular system was achieved in this single-rotation volume scan.

The effective dose for this chest scan was just 1.2 mSv.