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Advanced Medical Imaging Consultants

AMIC Educational Newsletter

PEDIATRIC IMAGING

Diagnostic Imaging: Ingested Foreign Body

I was Christmas shopping in Target the other day, perusing the board games aisle. A game called "Wild Woods" caught my eye. It had in large writing on the front of the game "WARNING: CHOKING HAZARD – Small Parts. Not for children under 3 years." Nearby was the game "Battleship". That games had hundreds of small parts, but there was no warning. Instead, it stated "AGES 7 +". I started thinking about why games have those warnings. In this article, I will briefly describe how those warnings on products are determined, and then show how imaging helps physicians treat children who accidently swallow or aspirate a foreign body.

Toys and games that are or contain small parts and that are intended for use by children between the age of 3 and 6 years old must be labeled with a warning not to be used by children under 3 because those children could choke. This regulation prevents deaths and injuries to children under three from choking on, inhaling, or swallowing small objects they may "mouth". These products include a wide range of articles such as toys, dolls, puzzles, nursery equipment, infant furniture, playpens and strollers. (2) If a manufacturer labels their product (game) as intended for ages 7 and up, then no warning is needed, even if there are small parts. Marbles, small balls, and balloons require this warning no matter what age the intended game is for.

Some products are exempt from a warning label: crayons, diaper pins and clips, eating utensils, and others because they cannot be manufactured in a way that would prevent them from breaking into small parts when subjected to use and abuse tests. A small part is any object which fits completely inside a specially designed test cylinder 2.25 inches long by 1.25 inches wide (approximately the size of throat of a child under three years old). (2)

Foreign-body aspiration is the most common cause of mortality owing to unintentional injury in children less than 1 year of age and results in approximately 3500 deaths per year in children of all ages. (1) The management of foreign-body *aspiration* is initially determined by clinical status. If the patient is stable, then a frontal chest x-ray is obtained. The most commonly aspirated foreign-bodies are food items: peanuts (35%-55%), seeds, and popcorn and then other food items. (1) Only 10% of aspirated foreign-bodies are radio-opaque. The remaining 90% must be identified using secondary imaging signs, which are: unilateral lung hyperinflation, atelectasis, mediastinal shift, and consolidation. Hyperinflation is the most common secondary sign, primarily due to increased compliance of the pediatric airway leading to a "ball-valve" mechanism. Additionally, a bilateral decubitus radiograph can be helpful in children who cannot cooperate with expiratory radiographs. The affected lung will not compress normally on the decubitus position due to the "ball-valve" effect of the foreign-body.

The first imaging step in suspected foreign-body *ingestion* is generally radiography. The initial standard imaging protocol is frontal and lateral radiographs of the chest, neck, and abdomen. CT may be considered if the type of object ingested is unknown, if no foreign body is seen on radiographs but there is a high clinical concern, or if there is concern for an abscess or obstruction.

Generally, if the foreign body is in the stomach or more distally, and does not have worrisome features (large size, length greater than 5 cm, sharp edges), no further imaging is indicated unless obstructive symptoms or peritonitis develops. If obstruction occurs, endoscopy is needed to remove the object. The most commonly ingested foreign-bodies are (from most to least common): coins, magnets, batteries, small toys, jewelry, buttons, and bones. (1) Fortunately, the most common ingested foreign-body, coins, generally are treated conservatively because they are don't

Common Ingested Objects

- Coins:
- Batteries
- Magnets
- Glass and sharp objects
- Lead Containing Objects

Ingested Foreign Body Cont'...

have sharp edges and are small. Ingested batteries, on the other hand, are treated aggressively. Disk batteries can produce currents that cause thermal injury to the esophagus, and urgent removal is indicated. (1) Esophageal damage can occur in as little as 1-2 hours. Confidently determining the difference between a coin and a disk battery is important information a radiologist conveys. Intact cylindrical batteries (AA, AAA) pose less risk than disk batteries for mucosal injury, and most pass through the GI tract without complication.

Magnets are another commonly ingested foreign body that can have serious health consequences. If one magnet is ingested, then it can be managed conservatively. However, if multiple magnets are ingested, magnets attracted across different loops of bowel wall can cause perforation and fistula formation. On plain films, magnets look like any other metallic object, therefore the location is important. Two small objects adjacent to each other should raise the concern for magnets. (Image 1)

Glass and sharp objects such as straight pins, needles, straightened paper clips, and hooks account for 5% to 35% of all swallowed objects. If the sharp object is proximal to the pylorus, they are removed endoscopically. If the object is lodged in the esophagus, it is dealt with as an emergency due to the devastating consequences of an esophageal perforation. If the object has made it into the small-bowel, it should be followed radiographically until it has passed out of the GI tract. Surgery is considered if the object has failed to progress through the bowel after 3 days.

Finally, lead-containing foreign objects are still something to remember when reviewing imaging for children. Commonly ingested foreign bodies that contain lead include fishing weights ("sinkers"), curtain weights, air-rifle pellets, some toys and medallions. A child in Minnesota died three years ago after she swallowed the medallion on her shoe, which was a sparkly pink colored trinket on the laces which was made of lead.

The holidays bring new toys to play with and explore, ornaments and decorating that are attractive to babies and toddlers that they might place in their mouth, and snacks and party food that are more available to children that might get aspirated. By knowing the important secondary signs for radiolucent aspirated objects, as well as being able to confidently identify commonly swallowed objects such as coins, batteries, sharp-objects, and lead products, the imaging department can provide valuable information to clinicians and help keep children healthy.

Michael Rogan, MD

Image 1:
2 y/o pt abdomen x-ray demonstrating round metallic objects in the right lower quadrant. Because they are in a row touching, magnets were considered. Surgery to remove them confirmed the objects were magnets.

Foreign-body aspiration is the most common cause of mortality owing to unintentional injury in children less than 1 year of age and results in approximately 3500 deaths per year in children of all ages.

References

1. Pugmire B, Lim R, Avery L. Review of Ingested and Aspirated Foreign Bodies in Children and Their Clinical Significance for Radiologists. Radiographics 2015;35:1528-1538
2. CPSC.gov website

CT: Appendix Imaging

Appendicitis is the most common surgical gastrointestinal emergency in children, peaking in incidence in the second decade of life (25 cases/10,000 children per year), which correlates with the peak of lymphoid follicles in the appendiceal submucosa. While it declines in frequency with age, the incidence of appendicitis persists throughout life. It is unusual in children less than seven years old, but is associate with greater rates of complication in that age group, as it can be a difficult diagnosis to make in younger children, and delayed diagnosis is associated with higher rates of perforation.

The appendix arises from the cecum. It is 6mm or less in cross section, and typically ranges from 5-10 cm in length, but can be as long as 30 cm. It is a reservoir for normal gut flora and is thought to aid in recovery from intestinal infections. The cecum is mobile and while the base of the appendix is fixed, the tip can be pelvic, intra- or extraperitoneal, leading to a wide range of clinical presentations and frequently requiring imaging studies to evaluate the cause of symptoms.

The classic presentation of appendicitis is abdominal pain, anorexia, fever and leukocytosis, frequently followed by vomiting and sometimes diarrhea. However, in children, up to 1/3 of patients do not present with the classic symptoms, and younger children can have a normal WBC.

At first, the abdominal pain is typically vague and with referred pain to the umbilicus through the visceral nerve fibers of the appendix in the T10 dermatome. As the peritoneal somatic sensory fibers become involved in the inflammatory process, the pain will localize to the right lower quadrant. If vomiting occurs before abdominal pain, gastroenteritis is more likely to be the cause of the patient's symptoms than appendicitis, and acute onset of severe pain is likely to be from another cause.

Appendicitis is thought to be secondary to luminal obstruction, frequently attributed to lymphoid hyperplasia, postulated to be due to dehydration and viral infection, but sometimes due to an appendicolith (present 15-40% of the time, see figure 1). An appendicolith is formed by post inflammatory precipitation of calcium salts in inspissated feces. There have been cases of outbreaks of appendicitis, suggesting that a primary infectious etiology can also be a cause. In addition, appendicitis is more common in those with a first degree relative with a history of appendicitis, suggesting a genetic component.

In the obstructed appendix, bacteria multiply and distend the appendix. The subsequent increase in intraluminal pressure causes venous congestion and ischemia, which can lead to perforation and possible abscess formation if not caught and treated early. Prehospital delays are more frequent than in-hospital delays in leading to rupture. However, early perforation can also occur rather than a progression from early to late appendicitis, suggesting two distinct etiologic disease processes. The rate of perforation in younger children is 80-100% at diagnosis, and 10-20% in children ages 10-17, with an overall rate of 20-35% in all patients. The mortality rate of appendicitis is 0.1-1% in children.

In the pediatric patient, the ALARA (as low as reasonably achievable) principal of radiation use is the goal. Because of this, graded right lower quadrant ultrasound is the first line of imaging in children, except in cases of obesity or suspected perforation or abscess, in which CT is the imaging modality of choice (see figure 2). Some institutions favor MRI over CT in children to avoid the risks of radiation, but it can be difficult to obtain optimal imaging in the uncooperative child with this modality. Unfortunately, the

Figure Two: Ultrasound demonstrates a blind ending, noncompressible tubular structure, consistent with an enlarged abnormal appendix

The appendix arises from the cecum. It is 6mm or less in cross section, and typically ranges from 5-10 cm in length, but can be as long as 30 cm. It is a reservoir for normal gut flora and is thought to aid in recovery from intestinal infections.

Figure One: Coronal CT image demonstrates appendicoliths throughout the enlarged appendix, including at the base. There is also abnormal wall enhancement.

Appendix Imaging Cont'...

appendix is often not identified with ultrasound due to shadowing from bowel gas and the variable position of the appendix, and CT is used for problem solving in those cases in which neither a normal nor abnormal appendix is identified and the clinical presentation is equivocal.

Because children often have little intra-abdominal fat, identification of the appendix is more difficult on CT, particularly when it is normal, and especially when there is respiratory or patient motion on the images. Explaining the procedure in a simple way and keeping the patient calm during the examination is helpful in minimizing motion.

The ileocecal valve is a useful landmark in identifying the appendix on imaging studies, as the origin of the appendix is 1-2 cm distal to and on the same side as the ileocecal valve. The abnormal appendix is greater than 6-7 mm in cross section. The wall of the inflamed appendix is typically hyper-enhancing, mildly thickened and associated with periappendiceal inflammation (see figure 3). Focal areas of nonenhancement of the appendiceal wall are consistent with ischemia, which increases the risk of perforation. Free fluid can be seen as reactive to the inflammation or can be present in cases of perforation, more commonly when there is extra-luminal gas associated with it, although extra-luminal gas is typically small in amount. Younger children are more likely than older children to have abscess formation, as the omentum is thought to prevent abscess formation in older children.

The treatment for acute uncomplicated appendicitis is antibiotics followed by surgery. In those with advanced cases, treatment with antibiotics and delayed appendectomy weeks to months later, sometimes with percutaneous abscess drainage, is performed (interval appendectomy). Outcome is typically excellent.

Despite advances in medical imaging, the negative appendectomy rate in children has not shown a significant decline, although studies have shown a decreased cost per patient and decrease in negative laparotomies in those who undergo advanced imaging, and radiology will continue to be helpful in improving diagnostic accuracy.

Becky Benz, MD

The ileocecal valve is a useful landmark in identifying the appendix on imaging studies, as the origin of the appendix is 1-2 cm distal to and on the same side as the ileocecal valve.

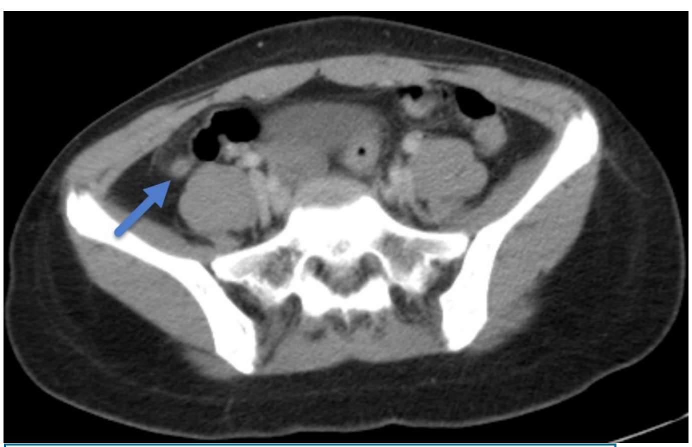


Figure Three: Axial CT Image demonstrates abnormal wall enhancement of the mildly enlarged appendix and adjacent inflammation.

Congenital Tarsal Coalition:
Multimodality Evaluation with Emphasis on CT and MR Imaging

Introduction

Tarsal coalition represents abnormal fusion between two or more tarsal bones and is a frequent cause of pediatric foot and ankle pain. Congenital tarsal coalition is a diagnosis that is often overlooked in young patients who first present with foot and ankle pain. In fact, coalitions of all types may be initially detected at computed tomography (CT) or magnetic resonance (MR) imaging examinations performed for an unrelated indication. Proper positioning of radiographs of the foot and proper scan and reconstruction planes on cross sectional imaging is necessary for proper diagnosis.

Congenital tarsal coalition results from abnormal differentiation and segmentation of embryonic tissue with resultant lack of the usual joint formation between two bones. Approximately 90% of tarsal coalitions involve the talocalcaneal (fusion of a portion of the talus and calcaneus) or calcaneonavicular (fusion of a portion of the calcaneus with the navicular) joints, nearly equal in number. Tarsal coalitions are subclassified on the basis of the cause of the abnormal bridging substance as either fibrous, cartilaginous, or osseous (depending on what structure is fusing the bones).

The onset of symptoms related to tarsal coalition is variable, and patients commonly present in the 2nd decade of life. Symptoms become more pronounced with progressive bony fusion of the coalition. Most patients present with hindfoot pain or stiffness. In some patients the tarsal coalition may be completely asymptomatic.

Radiography of Tarsal Coalition

All patients with suspected tarsal coalition are first evaluated with three radiographic views of the foot: anteroposterior, 45° internal oblique, and lateral films._ Use of conventional radiography alone may be sufficient to diagnose some calcaneonavicular and talonavicular coalitions. Proper positioning of the foot is necessary to evaluate the normal bony relationships.

Calcaneonavicular Coalition

Calcaneonavicular coalitions are best depicted on 45° internal oblique radiographs. The calcaneus and navicular do not normally articulate. With osseous coalition, a bony bar that bridges the two bones is seen. With fibrous or cartilaginous coalition, the bones are in close proximity, may have irregular surfaces, and the anteromedial calcaneus is abnormally widened or flattened. On lateral radiographs, elongation of the anterior dorsal calcaneus may simulate an anteater's nose. (Figures 1 and 2)

Talocalcaneal Coalition

The subtalar joint consists of the anterior, middle, and posterior facets. Talocalcaneal fusion most commonly involves the middle facet at the level of the sustentaculum tali . Talocalcaneal coalitions may be difficult to visualize on the three standard radiographic views of the foot because of the complex orientation of the subtalar joint. Secondary radiographic signs of talocalcaneal coalition may be present, including a talar beak (Figure 3) and lack of depiction of the middle facets on lateral radiographs.

CT of Tarsal Coalitions

CT of the ankle and hindfoot should be performed in both coronal (perpendicular to the ankle joint and long axis of foot) and axial (parallel to the ankle joint and long axis of foot) planes. The The AMIC MSK radiologists prefer the coronal images to be obtained both in a plane perpendicular to the plantar surface of the foot and additionally in a plane perpendicular to the plane of the subtalar joint. Section thickness should be approximately 3 mm.

Figure Three: Talar beak (secondary sign of talocalcaneal coalition

Approximately 90% of tarsal coalitions involve the talocalcaneal (fusion of a portion of the talus and calcaneus) or calcaneonavicular (fusion of a portion of the calcaneus with the navicular) joints, nearly equal in number.

Figure Two: Lateral Views show enlargement on the anterior dorsal calcaneus (anteater sign)

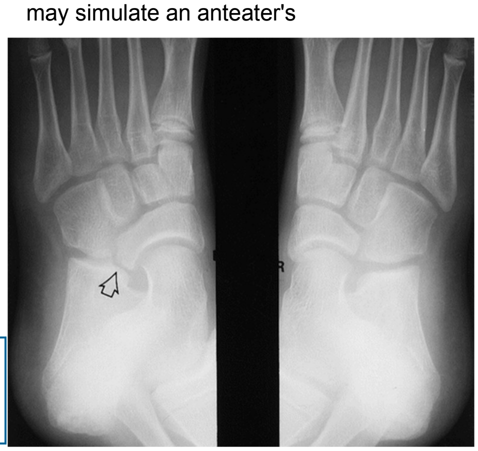
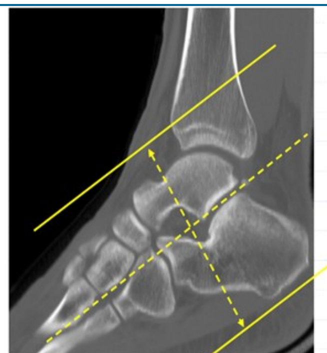


Figure One: Oblique films demonstrate a nonosseous coalition on the left.

Congenital Tarsal Coalition Cont'...

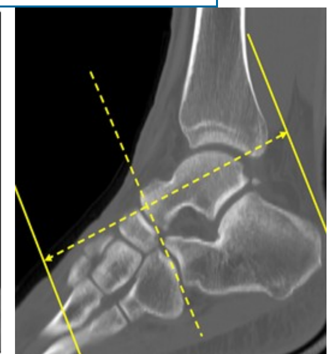
CT Imaging Planes:

Axial
Prescribe plane parallel to tibiotalar joint. Scan from distal tibia through beyond calcaneus

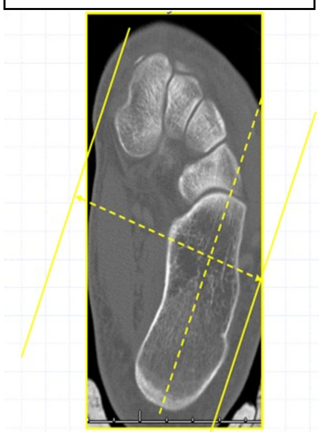


Axial Oblique Plane (recon)
Precribe plane parallel to subtalar joint (posterior facet) Recon from distal tibia through beyond calcaneus

Coronal Imaging Plane
Prescribe plane perpendicular to axial imaging plane
Scan ankle from calcaneus through metatarsal bases



Coronal Oblique Imaging Plane
Prescribe plane perpendicular to axial oblique plane (approx. parallel to midtarsal joints)
Scan from calcaneus through proximal metatarsals



Sagittal Oblique Imaging Plane
Prescribe plane with line bisecting calcaneus
Scan through entire foot

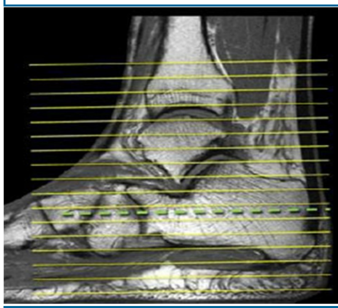
Proper positioning and reformats is essential for diagnosis of coalitions. (CT imaging planes detailed above).CT is invaluable in the diagnosis of talocalcaneal coalition and may be useful in surgical planning by helping determine if resection of the fusion material is feasible or if arthrodesis (surgical joint fusion) is indicated. CT offers a more precise evaluation of the extent of coalition, particularly at the subtalar joint, than does radiography. In talocalcaneal osseous coalition, a bony bar bridges the middle facet of the subtalar joint (Figure 5).._ In nonosseous (fibrous or cartilaginsous) coalition, the middle facet of the subtalar joint may be narrowed with reactive cystic and hypertrophic changes of the underlying bone. In calcaneonavicular coalition axial CT scans show broadening of the medial aspect of the anterior and dorsal calcaneus as it lies in close apposition to the navicular. The obliquity of the calcaneonavicular bridging, whether osseous or nonosseous, makes it difficult to visualize the entire coalition on only one axial or coronal image. Often the changes are subtle and only consist of narrowing of the space between the bones and some adjacent bony irregularity indicating an abnormal fibrous or cartilaginous fusion. (Figures Four)

Figures Four: Calcaneonavicular coalition in an 11-year-old boy. Axial and coronal CT scans show apposition of the anterior dorsal calcaneus with the navicular in the left foot, with narrowing and reactive sclerosis (arrow).

Figure Five: Talocalcaneal Coalitions. Coronal CT scnas show bilateral osseous coalitions (arrows) involving the middle facets.

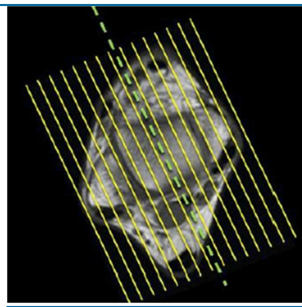
Congenital Tarsal Coalition Cont'…

MR Imaging Planes:



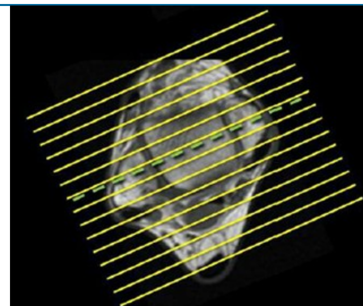
Axial Imaging Plane

Scan parallel to the long axis of the calcaneus. This is often the same plane as the bottom of the foot. Cover 4cm above the tibiotalar joint through the plantar skin



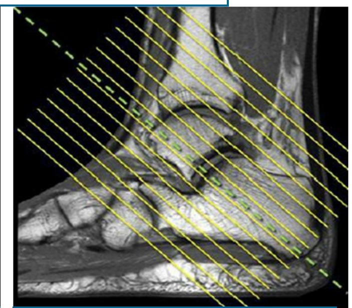
Sagittal Imaging Plane

The scan plane is perpendicular to the coronals. Scan medial to lateral to include all bones.



Coronal Imaging Plane

Use an image with both medial and lateral malleoli visible. The scan plan should split each of the three bones approximately in half. Cover the base of the metatarsals to the posterior skin



Axial Oblique Imaging Plane

The scan plane is perpendicular to the subtalar joint

Figure Six: Calcaneonavicular Coalition. Sagittal T1-weighted MR images shows the ant-eater sign

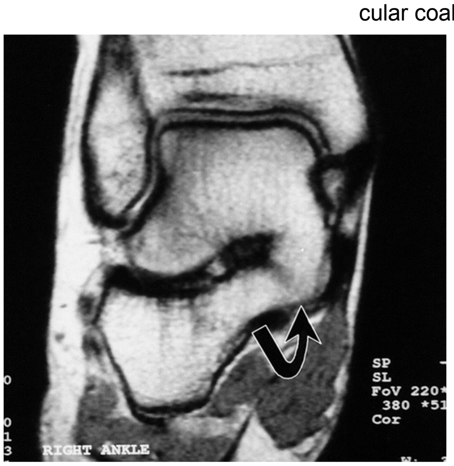


Figure Seven: Talocalcaneal coalition MRI: Coronal proton density-weighted MR image shows bone marrow contiguity (arrow) across the bridged middle facet

MR Imaging of Tarsal Coalitions

MR imaging of the ankle and hindfoot should be performed using our standard AMIC MRI Ankle Protocol utilizing four planes: axial, oblique axial, coronal, and sagittal. T1-weighted, fat suppressed fast spin-echo proton density–weighted, and fast spin-echo T2-weighted images with fat suppression are obtained. (MR imaging planes above)Tarsal coalitions are readily detected with these routine MRI sequences. Calcaneonavicular coalitions are best visualized on sagittal and axial MR images although sagittal images are particularly valuable because of the orientation of the calcaneonavicular bridging. The elongated anterior dorsal calcaneus (anteater's nose) may be visualized on a single sagittal image (Figure 6).. As in CT scanning, the plane perpendicular to the subtalar joints (the oblique axial plane on our protocol) is best for evaluating talocalcaneal coalitions with MR imaging (Figure 7).. In osseous coalitions, there is bone marrow contiguity across the fused articulation. In nonosseous coalitions, the joint space is reduced. In cartilaginous coalitions, an area of signal intensity similar to that of fluid or cartilage may be present in the joint space. Intermediate- to low-signal intensity in the affected joint may indicate a fibrous coalition. On proton density–weighted and T2-weighted fat-suppressed images or STIR images, bone marrowedema is frequently identified along the fused articulation.

Treatment

Initially, all patients with tarsal coalition are treated conservatively with orthotics, casting, nonsteroidal anti-inflammatory medications, steroid injections, or physical therapy. Many patients fail conservative therapy and are then treated operatively.

Summary

The vast majority of tarsal coalitions involve the calcaneonavicular or talocalcaneal joints. The initial diagnostic study of choice is three-view radiographs with proper positioning of the hindfoot necessary to evaluate the normal bony alignment. Given the complex anatomy of the hindfoot, CT or MRI examinations may be needed to evaluate hindfoot symptoms and often diagnose a coalition. The strict maintainance of proper coronal, axial, and sagittal imaging planes on CT and MRI is necessary to diagnose coalitions which may be subtle if not bony in nature.

Peter Koplyay, MD

US: Ultrasound of the Neonatal Brain

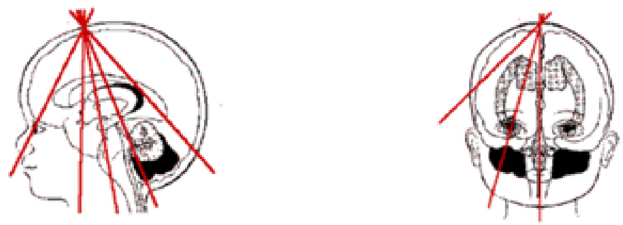
Cranial ultrasound is the most widely used neuroimaging procedure in premature infants. Ultrasound helps in assessing the neurologic status of the infant since clinical examination and symptoms are often non-specific. It gives information about the immediate and long term prognosis.

TECHNIQUE

Optimal imaging of the neonatal brain requires a good US window which in most preterm and many full-term infants includes the unfused cranial sutures and fontanelles. The anterior, posterior and mastoid (posterolateral) fontanelles are particularly useful. Anterior fontanelle is the largest fontanelle and typically fuses by 12 months of age. This is the window typically used for scanning. The proximity to the brain stem and posterior fossa afforded by the posterior and mastoid fontanelles allows use of higher frequency transducers, increasing resolution. Scanning is typically performed with 5-10 MHz transducers.

- Images are usually taken through the anterior fontanelle. The posterior fontanelle can be used if needed, and axial images are occasionally taken through the temporal bone.
- In the coronal plane, a series of images are taken through the frontal lobes, more posteriorly through the ventricles and thalami, then along the plane of the choroid plexus, then superior to that.
- That sagittal images are initially taken in the midline, with images then taken on both sides at the level of the lateral ventricles then periventricular areas. For the purposes of conversing space on this page, the left sagittal images have been omitted.

(Diagrams modified from Rennie JM Neonatal cerebral ultrasound. Cambridge University Press (1997). Used with permission from author.)



Additional images are taken according to clinical need

Fig 2—Normal sagittal gray-scale images of 7-day-old boy with seizures (same patient as figure 1)

A. Sonogram through the midline shows corpus callosum (straight arrows), hypoechoic structures bound by echogenic superior and inferior borders, cingulated gyrus (arrowheads), cavum septi pellucid (asterisk), occipital lobe (O), third ventricle (3) with choroid plexus in its roof (curved arrow), and fourth ventricle (4). Also noted are hypoechoic midbrain (M); pons (P), which has hyperechoic ventral hypoechoic dorsal regions; and cerebellar vermis (V)

B. Parasagittal sonogram through lateral ventricles shows caudothalamic groove (arrow), separating caudate nucleus (C) from thalamus (T), and choroid plexus along posterior margin of thalamus (dotted line). Note hyperechoic focus adjacent to lateral ventricle trigone that was not seen on coronal view (not shown). This periventricular pseudolesion (arrowhead) is commone artifact on this view)

C. Normal Peripheral sagittal gray-scale sonogram through Sylvian sulcus (dotted line) reveals temporal lobe (T), frontal lobe (F), and partial lobe (P). Note normal hypoechoic gray matter (arrow) between superficial hyperechoic pia and slightly hyperechoic white matter

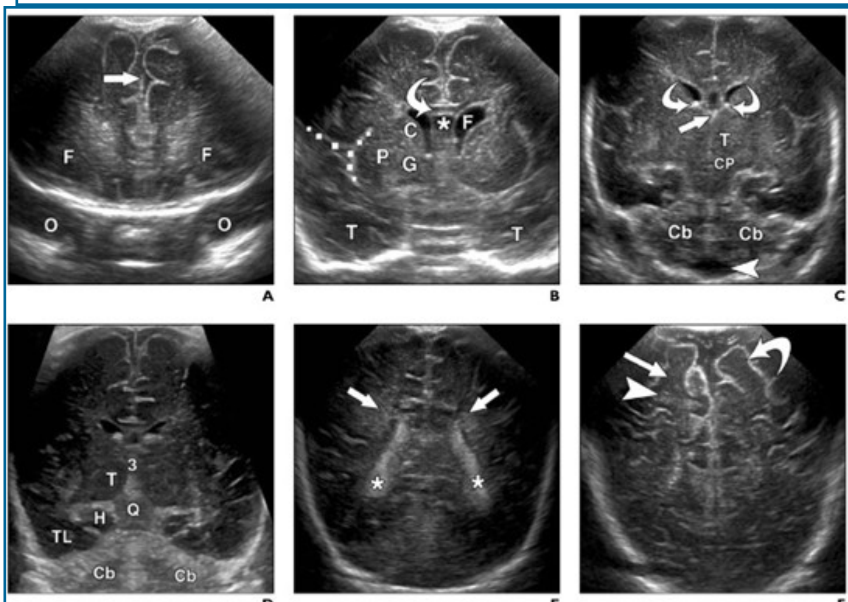


Figure 1—Normal coronal gray-scale images of 7 day old boy with seizures

A. Sonogram through frontal lobes (F) shows orbits (O) and hyperechoic falx cerebri (arrow) located within interhemispheric fissures.

B. Sonogram through frontal horns shows corpus callosum, seen as hypoechoic midline structure outlines by echogenic superior and inferior borders (arrow). Frontal horns (F), cavum septum pellucidum (asterisk), globus pallidus (G), putamen (P), caudate nucleus (C), temporal lobes (T), and Sylvian fissure (dotted line) are seen.

C. Sonogram at level of cerebral peducies identifies hyperechoic choroid plexus along roof of third ventricle (straight arrow) and floor of lateral ventricles (curved arrow). Also noted are left cerebral peduncle (CP), thalamus (T), cerebellar hemispheres (Cb), and cistern magna (arrowhead).

D. Sonogram at level of quadrigeminal plate (Q) illustrates temporal lobes (TL), cerebellar hemispheres (Cb), thalamus (T), hippocampus (H), and third ventricle (3).

E. Sonogram obtained through hyperechoic choroid plexus (asterisks) within lateral ventricles. Note less echogenic adjacent periventricular white matter (arrows). Periventricular white matter halo should normally be less echogenic than adjacent choroid plexus.

F. Sonogram through cerebral convexities reveals normal layers of cortex, which should be seen throughout brain. Well-defined hyperechoic pia (curved arrow) on surface of cortex overlies hypoechoic cortical gray matter (straight arrow), which overlies slightly hyperechoic white matter (arrowhead).

Ultrasound of the Neonatal Brain Cont'...

Cranial Ultrasound Interpretation:

Gray- Scale Imaging

It is important to be aware of the normal echogenicity of the various anatomic structures of the brain. First, gray matter tends to be hypoechoic and white matter tends to be hyperechoic. When this pattern is reversed, abnormality is indicated. Second, the normal brain is always symmetric, but symmetric is not always normal. This principle is helpful to avoid overlooking symmetric abnormalities such as bilateral hyperechoic thalami (Fig. 1) or bilateral hyperechoic cortex (Fig. 2) as can be seen with edema, ischemia or infarct. The third principle involves visualization of all layers of the normal cortex. The superficial pia mater should be seen as a thin well-defined hyperechoic layer overlying the hypoechoic cortical gray matter. Failure to distinctly visualize these normal layers is helpful to identify areas of abnormality such as focal hemorrhage or infarct (Fig. 2). Fourth, the periventricular white matter is normally homogeneous in echogenicity and equal to or less echogenic than the adjacent choroid plexus. Assymmetric, heterogenous or hyperechoic periventricular white matter suggests an abnormality as can be seen with periventricular leukomalacia (Fig. 4).

Amy Hayes, MD

Figure One: Echogenic basal ganglia

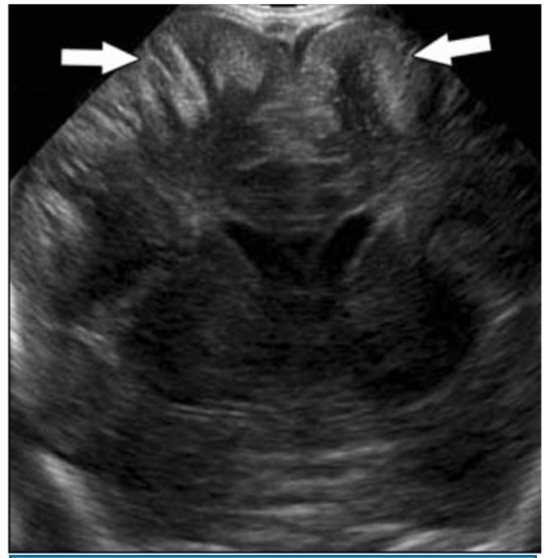


Figure Two: Bilateral hyperechoic cortex

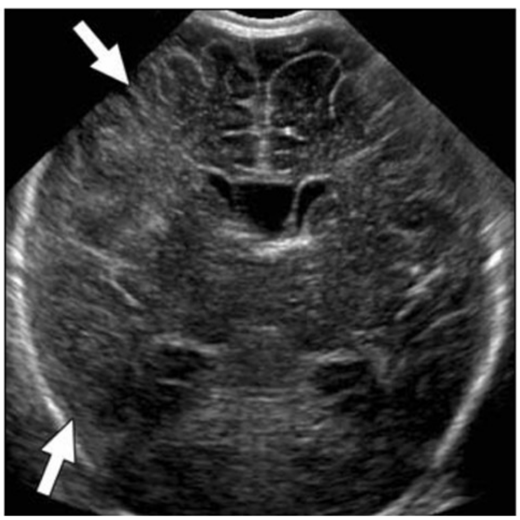


Figure Three: Indistinct cortex

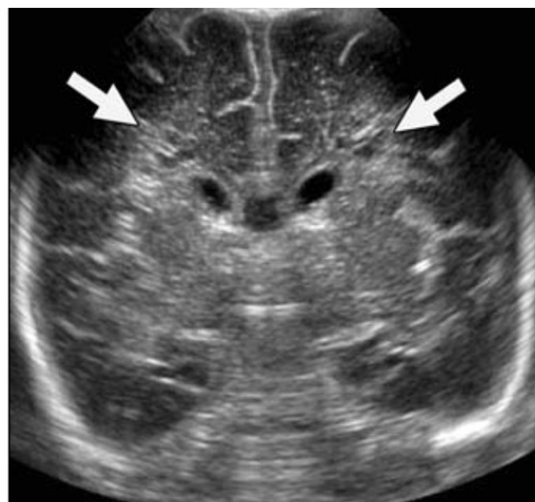


Figure Four: Periventricular echogenic white matter

Normal Echogenicity of Various Anatomic Structures of the Brain

1. **Gray matter tends to be hypoechoic and white matter tends to be hyperechoic**
2. **The normal brain is always symmetric, but symmetric is not always normal.**
3. **The superficial pia mater should be seen as a thin well-defined hyperechoic layer overlying the hypoechoic cortical gray matter.**
4. **The periventricular white matter is normally homogeneous in echogenicity and equal to or less echogenic than the adjacent choroid plexus.**

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