

Postgraduate Course
Diagnostic Imaging in 2009: Update on the Evidence-Based Practice of
Pediatric Imaging - Issues in Abdomen, Chest, Musculoskeletal and
Neuroimaging

Kimberly E. Applegate, MD, MS, Course Director

ABDOMINAL IMAGING OF COMMON CONDITIONS

The Role of Imaging in Pyloric Stenosis
Marta Hernanz-Schulman, MD

1. If Ultrasound results are equivocal for pyloric stenosis in a 2 week old infant, the child should

1. be referred for UGI
2. be referred to surgeon for additional abdominal palpation
- 3. be referred for follow-up US if vomiting worsens or continues**
4. be referred for scintigraphic "milk scan"

2. Abdominal palpation is most effective when performed

1. in infant with a distended stomach
2. in crying infant
3. by pediatrician
- 4. by pediatric surgeon**

References

1. White MC et al (1998) *Sensitivity and cost minimization analysis of radiology versus olive palpation for the diagnosis of hypertrophic pyloric stenosis.* J Pediatr Surg 33:913-917.
2. Macdessi J, Oates R (1993) *Clinical diagnosis of pyloric stenosis: a declining art.* BMJ 306:553-555.
3. O'Keeffe FN et al (1991) *Antropyloric muscle thickness at US in infants: what is normal?* Radiology 178:827-830.
4. Hernanz-Schulman M et al (1994) *Hypertrophic pyloric stenosis in the infant without a palpable olive: accuracy of sonographic diagnosis.* Radiology 193:771-776.
5. Hernanz-Schulman M. Pyloric Stenosis. A Review. Radiology. 2003; 227:319-331

Intussusception in Children: Evidence-based Diagnosis and Treatment

Kimberly E. Applegate, MD, MS

3. Which one of the following predicts a decreased chance of successful enema reduction in children with intussusception?

- A) Vomiting
- B) Age of child greater than one year
- C) Location of intussusception in hepatic flexure
- D) Duration of signs and symptoms greater than 48 hr**

The single most important clinical finding that predicts successful reduction of enema is the duration of symptoms. The longer the duration of symptoms beyond 24 hours, the lower the likelihood of successful enema reduction. Most literature suggests a significant delay is typically 48 hr of symptoms but some reports suggest 24 or 72 hours. **Option D is the best response.** Age less than 3 months is associated with both a higher perforation rate and a lower rate of successful reduction. Children beyond age 3 have higher risk of a pathologic lead point causing intussusception. **Option B is not the best response.** Other findings associated with lower reduction rates are dehydration and small-bowel obstruction. Lethargy often indicates dehydration and it is important to correct the child's dehydration to improve the enema intussusception reduction rate. Vomiting is one of the most common signs in children with intussusception and does not predict success or failure of enema reduction. **Option A is not the best response.** An intussusception encountered in the rectum has only a 25% reduction rate, but intussusceptions encountered elsewhere in the colon, including the hepatic flexure, can be expected to have a successful reduction rate of approximately 80%. The most common location to encounter idiopathic intussusception is at the hepatic flexure. **Option C is not the best response.**

References

1. Harrington L, Connolly B, Hu X, et al (1998) Ultrasonographic and clinical predictors of intussusception. J Pediatr 132:836-839
2. Navarro O, Daneman A (2004) Intussusception Part 3:Diagnosis and management of those with an identifiable or predisposing cause and those that reduce spontaneously. Pediatr Radiol 34:305-312
3. Del-Pozo G, Gonzalez-Spinola J, Gomez-Anson B, et al (1996) Intussusception: trapped peritoneal fluid detected with US - relationship to reducibility and ischemia. Radiology 201:379-383
4. Shiels WE II, Maves CK, Hedlund GL, et al (1991) Air enema for diagnosis and reduction of intussusception: clinical experience and pressure correlates. Radiology 181:169-172
5. Daneman A, Navarro O (2004) Intussusception Part 2: an update on the evolution of management. Pediatr Radiol 34:97-108
6. Applegate KE. Clinically suspected intussusception in children: evidence-based review and self-assessment module. AJR Am J Roentgenol. 2005 Sep;185(3 Suppl):S175-83. Review.

Optimizing the Role of Imaging in Appendicitis

Andrea S. Doria, MD

4. Which one of the following research designs relates to the statistical analysis of a collection of independent studies to produce a single estimate of the effect of the health care under consideration?

- A. Systematic review
- B. Meta-analysis**
- C. Pooled analysis
- D. Narrative overview

Rationale

The correct answer is B.

With regard to types of review articles, the most generic ones are narrative overviews, followed by systematic reviews, meta-analyses, and pooled analyses.

Option D is not correct. A narrative overview is a potentially biased nonstructured literature review on a specific topic that pursues a broad research question and provides a qualitative summary of the literature in the field (1).

Option A is not correct. A systematic review is a review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research and collect and analyze data from studies included in the review (1).

Option B is correct. Statistical methods may or may not be used to analyze and summarize results of the included studies. If statistical techniques are applied in a systematic review, this review is named a meta-analysis (2). The primary objective of a meta-analysis is the estimation of summary effect (synthetic goal) or the estimation of differences (analytic goal).

Option C is not correct. A pooled analysis is a meta-analysis based on individual-level patient data, rather than individual study data (3).

References

1. Klassen TP, Jadad AR, Moher D. Guides for reading and interpreting systematic reviews: I. Getting started. *Arch Pediatr Adolesc Med* 1998; 152: 700-704
2. Huque MF. Experiences with meta-analysis in NDA submissions. *Proc Biopharmaceutics Soc Am Stat Assoc* 1988; 2: 28-33
3. Petitti DB. Planning the study. In: Petitti DB. *Meta-Analysis, Decision Analysis, and Cost-Effectiveness Analysis. Methods for Quantitative Synthesis in Medicine*. New York, NY: Oxford University, 2000; 33-42
4. Egger M, Smith GD, O'Rourke K. Rationale, potentials, and promise of systematic reviews. In: Egger M, Smith GD, Altman DG, eds. *Systematic Reviews in Health Care. Meta-Analysis in Context*. London: BMJ, 2001: 3-19
5. Hearst N, Grady D, Barron HV, Kerlikowske K. Research using existing data: secondary data analysis, ancillary studies, and systematic reviews. In: Hulley SB,

Cummings SR, Browner WS, Grady D, Hearst N, Newman TB, eds. *Designing Clinical Research*. Philadelphia, PA: Lippincott Williams & Wilkins, 2001; 195–212

Imaging Choices in Inflammatory Bowel Disease
Sudha A. Anupindi, MD

5. Which of the following procedures would provide the highest diagnostic accuracy in the evaluation of complications of IBD without the use of ionizing radiation?

- A) Capsule Endoscopy
- B) Ultrasound
- C) MR enterography**
- D) CT enteroclysis

Rationale

Answer is C.

- CT enteroclysis uses ionizing radiation and does not apply in the question.
- Wireless capsule endoscopy is not formal imaging and provides a endoluminal evaluation of the bowel. Currently it is not routinely used in the work-up of children with suspected IBD but is preferentially used when the diagnosis is unclear. WCE also is limited in it does not provide a look at extraluminal pathology [3].
- US has a overall sensitivity 85% in detecting ileal stenoses. The sensitivity and specificity of US in detecting abscesses was 90.91% and 84.62% respectively [1]. The accuracy of US is comparable to CT but CT shows higher specificity and positive predictive value with the use of ionizing radiation The results from a retrospective study by Potthast et al. shows that MRI is superior to ultrasound in the localization of affected bowel segments (sensitivity: MRI 97.5%; US 76%) and in recognizing fistulae (sensitivity: MRI 87%; US 31%), stenoses (sensitivity: MRI 100%; US 58%) and abscesses (sensitivity: MRI 100%; US 89%) [2].

References

1. Alison, M., et al., *Ultrasonography of Crohn disease in children*. *Pediatr Radiol*, 2007. 37(11): p. 1071-82.
2. Potthast, S., et al., *Ultrasound and magnetic resonance imaging in Crohn's disease: a comparison*. *Eur Radiol*, 2002. 12(6): p. 1416-22.
3. Hara, A.K., et al., *Crohn disease of the small bowel: preliminary comparison among CT enterography, capsule endoscopy, small-bowel follow-through, and ileoscopy*. *Radiology*, 2006. 238(1): p. 128-34.

Pancreatitis and the Role of US, MRCP and ERCP

Kassa Darge, MD, PhD

6. Which of the following statements is FALSE regarding normal finding in MR cholangiopancreatography [MRCP] with intravenous administration of secretin:

- A. The fluid signal in the pancreatic duct increases.
- B. The diameter of the pancreatic duct increases.
- C. The detection of side branches of the pancreatic increases.
- D. Pancreatic duct contour becomes more distinct.
- E. **The amount of fluid in the duodenum decreases.**

Rationale

Answer is E.

Secretin, a polypeptide hormone, induces increased fluid signal in pancreatic duct and subsequent fluid excretion into the duodenum. It is administered intravenously slowly over 1 minute at a dose of 0.2 µg/kg body weight (maximum 16 µg) [1]. T2 coronal images along the pancreatic duct are repeated every 30 sec for 10 min. The normal response is increase in signal and diameter of pancreatic duct up to 3 mm in 3-5 min with progressive decline to baseline in 10 min. Secretin is probably more important in children than in adults as it increases the detectability of the normally smaller pancreatic ducts. 15 children, 6-17 years old, with idiopathic chronic pancreatitis underwent MRCP before and after secretin administration [2]. The number of main pancreatic duct segments visualized on MRCP was 24/45 (53%) before and 42/45 (93%) after administration of secretin. The visualization of the duct of Santorini increased from 1/15 (7%) to 8/15 (53%) of patients after secretin administration. The detection of side branches increased from 20% to 47%, too. The conspicuity of cavities and main pancreatic duct contour irregularity improved, too.

References

1. Chavhan GB, Babyn PS, Manson D et al. (2008) Pediatric MR cholangiopancreatography: principles, technique, and clinical applications. *RadioGraphics* 28:1951-1962
2. Manfredi R, Lucidi V, Gui B, et al (2002) Idiopathic chronic pancreatitis in children: MR cholangiopancreatography after secretin administration. *Radiology* 224:675-682
3. Delaney L, Applegate KE, Karmazyn B, Akisik MF, Jennings SG. MR cholangiopancreatography in children: feasibility, safety, and initial experience. *Pediatr Radiol.* 2008 Jan;38(1):64-75.

Abdominal Trauma Imaging: Imaging Choices and Appropriateness
Carlos J. Sivit, MD

7. *Which CT finding is diagnostic of active hemorrhage?*

- A. Large hemoperitoneum
- B. Fluid attenuation 60-90 H.U.
- C. **Fluid attenuation > 90 H.U.**
- D. Grade III hepatic injury

Reference:

1. Taylor GA, Kaufman RA, Sivit CJ: Active hemorrhage in children after thoracoabdominal trauma: clinical and CT features. *AJR Am J Roentgenol* 1994;162:401-404

Special Focus Session on Malrotation: Definition, Variability, and the Role of Imaging

Kimberly E. Applegate, MD, MS, Alan Daneman, MD, Stephen B. Shew, MD, David K. Yousefzadeh, MD

8. *What is the accuracy of the Upper Gastrointestinal Series to diagnose or exclude malrotation in infants and children?*

- A) No false positives
- B) No false negatives
- C) **5% false negative rate**
- D) 5% false positive rate

While there are few publications reporting sensitivity and specificity of imaging for malrotation, several compare the UGI series reports to the surgical findings. No test is perfect so **options A and B are not the best responses**. The reported false negative rates are low, at 3-6%. **Option C is the best response**. In contrast, the reported false positive rate is higher at 15%. The UGI series diagnosis of malrotation is a critical one in order to avoid life threatening volvulus. Therefore, the three-fold greater false positive rate is an appropriate one for this clinical condition. **Option D is not the best response**. Ultimately however, the accuracy of an individual pediatric radiologist depends on the local patient population, the UGI technique used, and the skill and experience in interpretation of the findings. The peer reviewed literature should serve as a benchmark for groups and individuals who perform this test to diagnose or exclude malrotation.

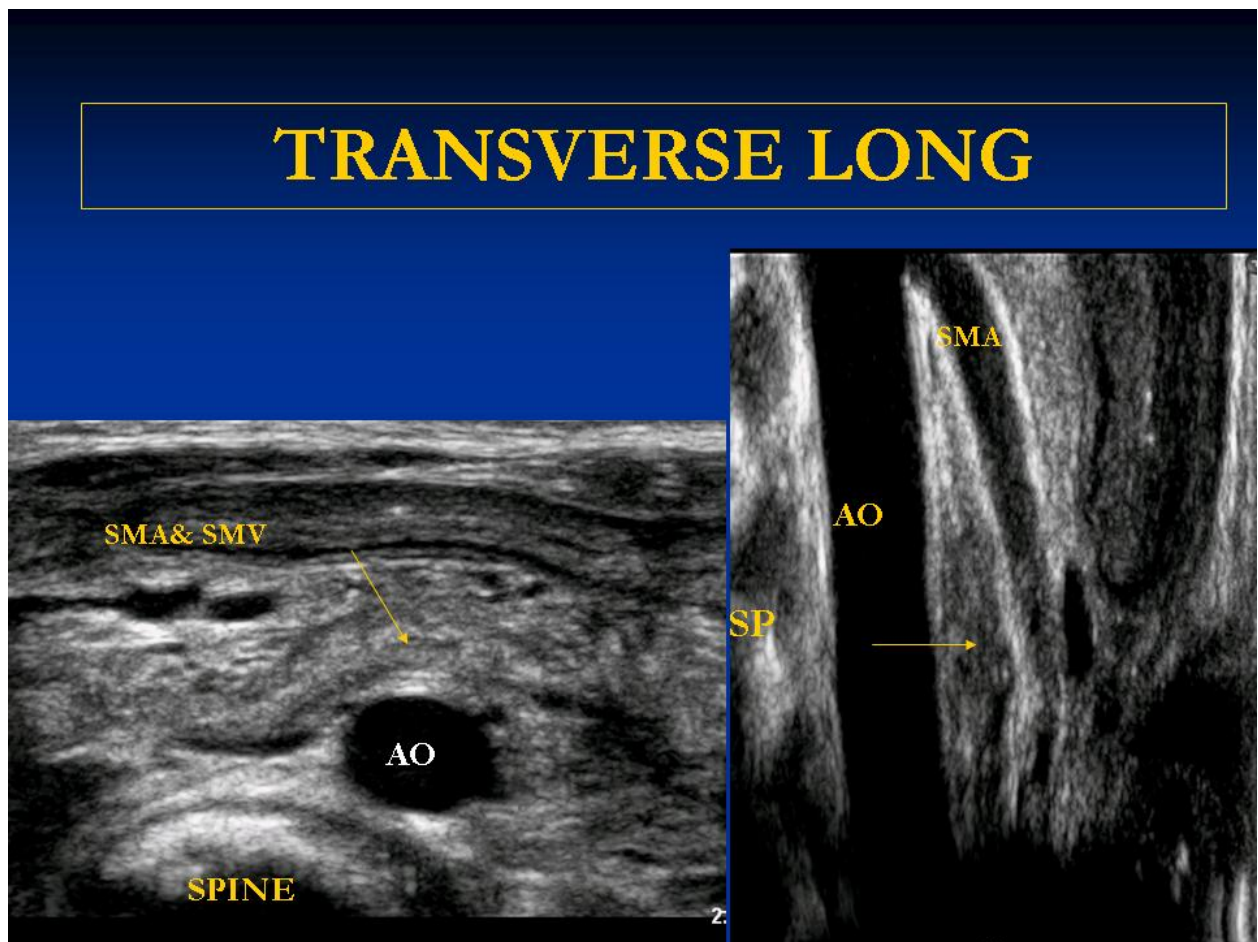
References

1. Strouse PJ. Disorders of intestinal rotation and fixation ("malrotation"). *Pediatr Radiol* 2004;34(11):837-51
2. <http://www.cdc.gov/mmwr/PDF/ss/ss4201.pdf> [last accessed November 2008]

3. Sizemore A, Rabbani KZ, Ladd A, Applegate KE. Diagnostic Performance of the Upper Gastrointestinal Series in the Evaluation of Children with clinically suspected malrotation. *Pediatr Radiol.* 2008;38(5):518-28
4. Applegate KE, Anderson JA, Klatte E. Malrotation of the gastrointestinal tract: A problem solving approach to performing the upper GI series. *RadioGraphics* 2006;26:1485-1500
5. Katz ME, Siegel MJ, Shackelford GD, McAlister WH. The position and mobility of the duodenum in children. *AJR Am J Roentgenol* 1987;148(5):947-51

9. *You are shown a midline axial and longitudinal US image of a newborn abdomen. Which anatomic structure is shown by the arrow?*

- A. Transverse colon
- B. Uncinate process of the pancreas
- C. First jejunal loop
- D. The 3rd portion of the duodenum**
- E. All of the above

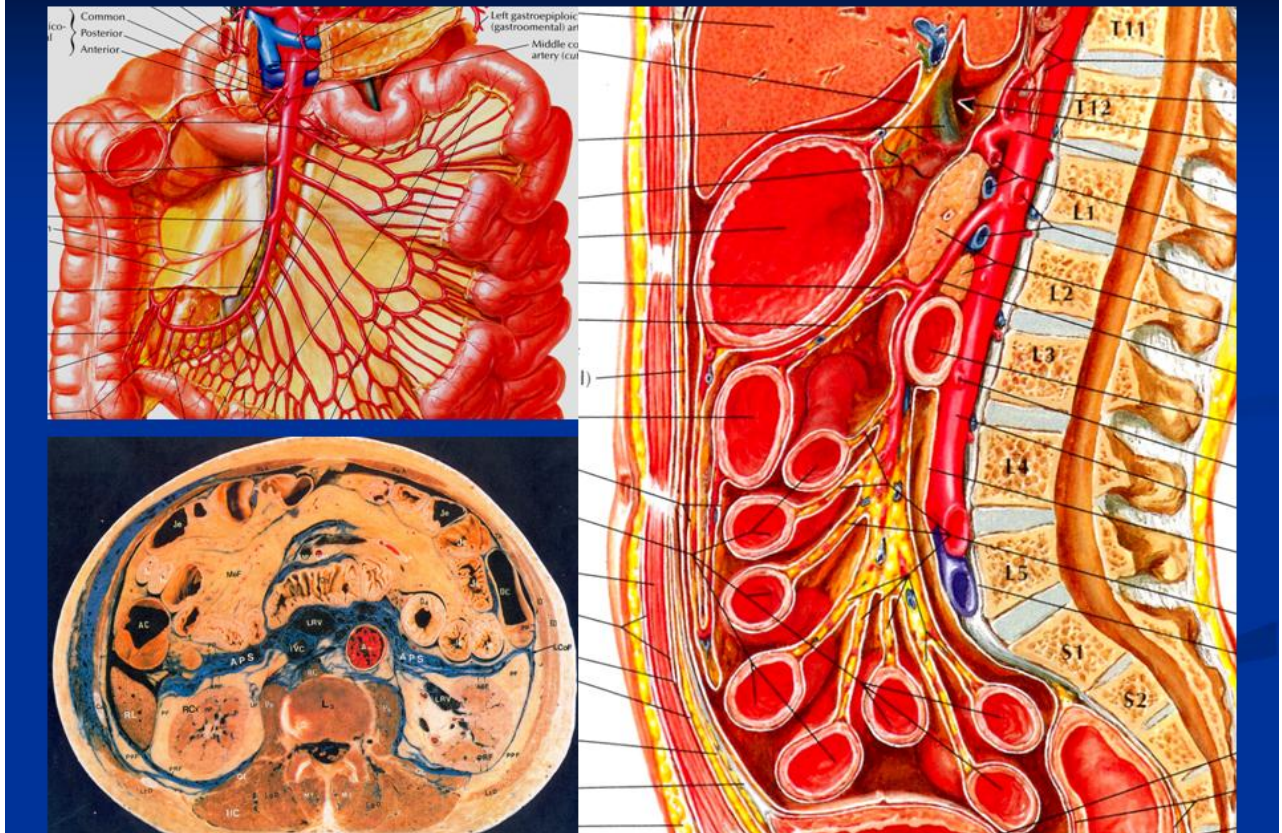


Rationale:

The answer is D.

The mucosal pattern & muscularis exclude the uncinata of the pancreas, leaving a bowel loop as the only alternative. The only bowel loop that is situated between AO & SMA is the 3rd portion of the duodenum, indicating that the gut has reached its final embryologic destination, fixed in retroperitoneal space, and not being prone to volvulus. The jejunum & transverse colon are both anterior to the SMA.

Normal anatomic position of the transverse duodenum



Reference:

1. Jayaraman MV, Mayo-Smith WW, Movson S, Dupuy DE, Wallach MT (2001) CT of the duodenum: An overlooked segment gets its due. *RadioGraphics* 21:S147-S160

“If there is abnormal rotation, the duodenum does not cross the midline but remains in the right side of the abdomen.”

“Malrotation is reliably imaged at CT when the duodenum is not visible between the aorta and the superior mesenteric artery, an anatomic relationship that is consistently seen on all abdominal CT scans with normal findings.”

CHEST IMAGING IN COMMON CONDITIONS

What Imaging Should We Perform for the Diagnosis and Management of Pulmonary Infections?

Sjirk J. Westra, MD

10. *Differentiation between a viral and a bacterial etiology of pneumonia in a child is based on:*

- A. Height of fever: a high fever favors bacterial and a low-grade fever viral
- B. Distribution of lung opacities: localized in bacterial and widespread in viral
- C. Type of lung opacity: alveolar is seen in bacterial and interstitial in viral
- D. Age: young children get viral and older children bacterial pneumonias
- E. **None of the above criteria: there is too much overlap**

Rationale

Answer is E.

Whereas the above-mentioned criteria are helpful to differentiate viral from bacterial pneumonia and are broadly applicable, there is too much overlap in these to be clinically useful in individual patients.

Option A is not correct. A substantial proportion of children with viral pneumonias present with high fever [1, 2]

Options B, C and D are not correct. Lung response to an infective antigen appears to be more age-specific than antigen (i.e. bacteria vs. viral) dependent. In a study of 254 children admitted with a diagnosis of community acquired pneumonia, to evaluate the role of clinical parameters and chest radiography, 71% of children with lobar opacities demonstrated laboratory evidence of a bacterial infection, but interstitial opacities were seen with approximately equal frequencies in viral and bacterial pneumonias. Of children less than 2 years, 38% had bacterial infections and 60% viral, whereas in older children bacterial pneumonias were more prevalent (49%) than viral (22%), the remainder being of mixed etiology [3]. In another study of 61 children treated for radiologically and microbiologically confirmed viral or bacterial pneumonia, 74% of the patients with alveolar and 62% with interstitial pneumonia had bacterial infection. An interstitial pattern of pneumonia on chest radiographs was nonspecific: it was due to viral (26%), bacterial (30%) or mixed (44%) etiologies [4].

References

1. McIntosh K (2002) Community-acquired pneumonia in children. The New England journal of medicine 346:429-437.
2. McCracken GH, Jr. (2000) Diagnosis and management of pneumonia in children. *Pediatr Infect Dis J* 19:924-928.
3. Virkki R, Juven T, Rikalainen H, et al. (2002) Differentiation of bacterial and viral pneumonia in children. *Thorax* 57:438-441.
4. Korppi M, Kiekara O, Heiskanen-Kosma T, et al. (1993) Comparison of radiological findings and microbial aetiology of childhood pneumonia. *Acta Paediatr* 82:360-363.

11. You are shown the following chest radiographs in four different children with complicated pneumonias. Using evidence-based reasoning, the following additional studies are indicated for further evaluation

- A. Frontal decubitus radiographs to demonstrate shifting of effusions in 1 and 2
- B. Ultrasound to demonstrate complexity of effusion in 3, and to guide thoracostomy tube placement
- C. CT to better characterize empyema in 3, and to guide thoracostomy tube placement
- D. CT to better characterize opportunistic infection in 4**
- E. Upright radiograph to show fluid level in lung abscess in 1

Rationale

Answer is D.

CT is indicated in immunocompromized patients with pneumonia, both for allowing an earlier diagnosis than on chest radiography, and to better characterize the type of infection [1, 2].

Option A is not correct. Decubitus radiographs have limited value in large effusions, when the underlying lung is markedly consolidated.

Option B and C are not correct. Ultrasound and CT are helpful for pleural collections [3-5], not for an intraparenchymal abscess, as in patient 3.

Option E is not correct. The radiograph in patient 4 shows a pleural collection (empyema), not a parenchymal abscess.

References

1. Winer-Muram HT, Arheart KL, Jennings SG, et al. (1997) Pulmonary complications in children with hematologic malignancies: accuracy of diagnosis with chest radiography and CT. *Radiology* 204:643-649.
2. Barloon TJ, Galvin JR, Mori M, et al. (1991) High-resolution ultrafast chest CT in the clinical management of febrile bone marrow transplant patients with normal or nonspecific chest roentgenograms. *Chest* 99:928-933.
3. Ramnath RR, et al. (1998) Implications of early sonographic evaluation of parapneumonic effusions in children with pneumonia. *Pediatrics* 101:68-71.
4. Tan Kendrick AP, et al. (2002) The value of early CT in complicated childhood pneumonia. *Pediatr Radiol* 32:16-21.
5. Kearney SE, et al., (2000) Computed tomography and ultrasound in parapneumonic effusions and empyema. *Clin Radiol* 55: 542-547.

Evaluation of Non-Vascular Mediastinal Masses In Infants and Children: An Evidence-Based Practical Approach
Edward Y. Lee, MD, MPH

12. *You are shown AP and lateral views of chest radiographs (See Figures 1A and 1B), axial and coronal contrast enhanced CT images (See Figures 2A and 2B), and coronal T1 fast spin-echo inversion recovery (FSEIR) sequence image of a 5-year-old boy with shortness of breath and chest pain. Which one of the following is the MOST likely etiology of the symptoms in this child?*

- A. Teratoma
- B. Bronchogenic cyst
- C. Lymphoma
- D. Right upper lobe collapse
- E. **Neuroblastoma**

Rationale

Answer is E.

AP chest radiograph (Figure 1A) shows an opacity projecting over the right upper lung zone with associated mild mass-effect upon the right side of the trachea in the absence of substantial volume loss within the right hemithorax. Lateral chest radiograph (Figure 1B) demonstrates that this opacity is located within the posterior mediastinum with associated mild mass-effect on the posterior aspect of the trachea. Subsequently obtained contrast enhanced CT images (Figures 2A and 2B) demonstrate a soft tissue mass located within the right posterior mediastinum extending into the neural foramen. Coronal FSEIR MR image (Figure 3) confirms the extension of the mass into the upper and mid thoracic neural foramina. Constellations of these findings are most consistent with a neurogenic tumor, particularly neuroblastoma with neuroforaminal extension in this patient's age group.

Option A is not correct. Teratoma is usually located within the anterior mediastinum and typically presents as a heterogeneous mass consisting of cystic and solid as well as fat and irregular calcification. Posterior mediastinal location of the relatively homogeneous soft tissue mass without associated fat, fluid or calcific components does not support the diagnosis of teratoma. Furthermore, most anterior mediastinal germ cell tumors (e.g. teratoma) are benign without tumoral extension into the neural foramen in children.

Option B is not correct. Bronchogenic cysts typically present as well-circumscribed round or oval shaped cystic masses located within the middle mediastinum. Posterior mediastinal location of the mass and relatively homogeneous soft tissue attenuation do not support the diagnosis of bronchogenic cyst. Further, bronchogenic cysts do not typically have a connection / extension into the adjacent neural foramen.

Option C is not correct. Lymphoma is usually located within the anterior mediastinum with possible extension into the middle mediastinal compartment. Furthermore, lymphoma typically presents as a homogeneous soft tissue mass without neural foraminal extension.

Option D is not correct. Right upper lobe collapse can often present as an opacity projecting over the right upper lung zone. However, right upper lobe collapse is typically associated with ipsilateral lung volume loss. In this case, a space-occupying opacity with associated mass effect upon adjacent mediastinal structures (i.e., trachea) without associated volume loss are not consistent with the findings typically seen in patients with right upper lobe collapse. Subsequently obtained CT and MR studies confirm that the right upper lobe opacity is not the collapsed portion of lung, but the soft tissue mass.

References

1. Meza MP, Benson M, Slovis TL. Imaging of mediastinal masses in children. *Radiol Clin North Am* 1993; 31:583 - 604
2. Laurent F, Latrabe V, Lecesne R, et al. Mediastinal masses: diagnostic approach. *Eur Radiol* 1998; 8:1148 - 1159
3. Erasmus JJ, McAdams HP, Donnelly LF, Spritzer CE. MR imaging of mediastinal masses. *Magn Reson Imaging Clin N Am* 2000; 8:59 - 89
4. Williams HJ, Alton HM. Imaging of paediatric mediastinal abnormalities. *Paediatr Respir Rev* 2003; 4:55 - 66

What is the Optimal Imaging for Vascular Rings and Slings?

Lorna P. Browne, MB BCH BAO, FFRCSI

13. What is the best imaging modality for Pulmonary Sling?

- A. CTA
- B. MRI with MRA
- C. Bronchoscopy
- D. Conventional Angiography with bronchoscopy

Rationale:

MDCT Angiography has a sensitivity of 100% compared with bronchoscopy for identification of tracheomalacia[1]. The presence of a bridging bronchus is highly associated with the presence of complete cartilaginous rings, MDCT has been demonstrated to be better than bronchoscopy for the identification of these lesions [2]. In addition CTA has the advantage of the ability to identify lesions distal to obstructions not passable by the bronchoscope, can see the secondary effects such as collapse/air trapping/ mucus plugging of a proximal obstructive lesion on the distal airways and lungs. The extent of the airway abnormalities demonstrated on pre-operative assessment will determine whether a tracheal repair is undertaken [3].

References:

1. Lee EY, Mason KP, Zurakowski D et al (2008). MDCT assessment of tracheomalacia in symptomatic infants with mediastinal aortic vascular anomalies: preliminary technical experience. *Pediatr Radiol.* 38:82-8.
2. Baden W, Schaefer J, Kumpf M et al (2008) Comparison of imaging techniques in the diagnosis of bridging bronchus. *Eur Respir J.* 31:1125-31
3. Fiore AC, Brown JW, Weber TR et al. (2005) Surgical treatment of pulmonary artery sling and tracheal stenosis. *Ann Thorac Surg Jan;*79:38-46

CARDIAC AND FETAL IMAGING

The Role of MRI and CT in Congenital Heart Disease

Rajesh Krishnamurthy, MD

14. Predictors of impaired clinical status in repaired Tetralogy of Fallot include all the following except:

- A. RV systolic dysfunction (RV EF < 45%)
- B. LV systolic dysfunction (LV EF < 50%)
- C. Increased QRS duration on the EKG >180 ms
- D. Pulmonary regurgitant fraction >35%**
- E. Increased age at initial repair (>12 years)

References:

1. Geva T, Sandweiss BM, Gauvreau K, Lock JE, Powell AJ. Factors associated with impaired clinical status in long-term survivors of tetralogy of Fallot repair evaluated by magnetic resonance imaging. *J Am Coll Cardiol*, 2004;43:1068-1074.
2. Knauth AL, Gauvreau K, Powell AJ, Landzberg MJ, Walsh EP, Lock JE et al. Ventricular size and function assessed by cardiac MRI predict major adverse clinical outcomes late after Tetralogy of Fallot repair. *Heart* 2008;94:211-216
3. Murphy JG, Gersh BJ, Mair DD, Fuster V, McGoon MD, Ilstrup DM et al. Long-Term Outcome in Patients Undergoing Surgical Repair of Tetralogy of Fallot. *NEJM.* 1993;329:593-599

What is the Evidenced Based Role of US in Evaluating the Fetus?

Dorothy I. Bulas, MD

15. Which of the following decreases the sensitivity of ultrasound in identifying a fetal anomaly.

- A. Experienced sonographer
- B. High prevalence of a defect
- C. Polyhydramnios
- D. Maternal obesity**

Rationale

Answer is D.

Maternal body habitus affects the US imaging of the fetus. With maternal obesity, lower mHz transducers need to be used, decreasing resolution. While transvaginal probes may aid in assessment of the fetus in this scenario, fetal lie may limit visualization of the entire fetus.

Option A is not correct. Experience of the sonographers had a measurable impact on anomaly detection. In the RADIUS Study Group, highly experienced sonographers detected 35% of anomalies compared with only 13% by less experience sonographers (1). Thus, the skill of the sonographer is an important factor in the sensitivity and specificity of US assessment of the fetus. A comprehensive, detailed exam is needed for adequate assessment of the entire fetus

Option B is not correct. Increased prevalence of a defect improves the likelihood of identifying an anomaly.

Option C is not correct. While polyhydramnios may make scanning somewhat difficult due to increased movement of the fetus, increased fluid can be useful in assessing the fetal face and limbs. Fluid about the face increases the success of 3D/4D scanning. Oligohydramnios markedly decreases the sensitivity and specificity of US assessment particularly in the evaluation of the fetal face and limbs.

References

1. Crane JP, LeFevre ML, Winborn RC, et al. A randomized trial of prenatal ultrasonographic screening: impact on the detection, management, and outcome of anomalous fetuses. The RADIUS Study Group. *Am J Obstet Gynecol* 1994;171:392-9.
2. Bricker L, Neilson JP Routine US in late pregnancy after 24 weeks gestation Cochrane Database of Systematic review 2007 18;(2):CD001451
3. Van Dorsten JP; Hulsey TC; Newman RB; et al Fetal anomaly detection by second-trimester ultrasonography in a tertiary center *Am J Obstet Gynecol* 1998 ;178(4):742-9.
4. Sabbagha RE Sheikh Z, Tamura RK: Predictive value sensitivity and specificity of US targeted imaging for fetal anomalies in gravid women at high risk for birth defects *AM J OBstet Gynecol* 1985;152:822-827
5. Garne E; Loane M; Dolk H; et al Prenatal diagnosis of severe structural congenital malformations in Europe. *Ultrasound Obstet Gynecol* 2005 Jan;25(1):6-11.

MUSCULOSKELETAL IMAGING OF COMMON CONDITIONS

The Role of Radiographs and US in Developmental Dysplasia of the Hip: How Good are They?

Marc S. Keller, MD

16. *Evidence exists for added value of neonatal hip US imaging in which of the following conditions?*

- A. Neonatal hip click
- B. Neonate with DDH risk factor (breech position, positive family history, clubfoot)**
- C. Positive Barlow or Ortolani sign
- D. Asymmetric thigh creases

Rationale

Answer is B.

In the 2 sizeable randomized controlled studies listed, which included a total of 27,454 babies, a trend toward lowering late emergence of DDH was noted in both trials. Study cohorts that selected neonates for hip sonography with risk factors of breech position just before birth, a positive family history of DDH and postural or positional abnormalities such as clubfoot showed a two-fold and a four-fold reduction in late diagnosis of DDH when compared to clinical-only screening.

Option A is not correct. Neonatal hip clicks and neonatal hip laxity are benign physical findings which resolve spontaneously and have not been shown to correlate with late diagnosis of DDH.

Option C is not correct. Clinical diagnosis of DDH in neonates should lead directly to treatment and followup under orthopedic care. No significant improvement in outcome has been shown in babies with DDH who get confirmatory diagnostic hip sonograms.

Option D is not correct. While asymmetry in the thigh creases may be an ancillary finding in DDH, there is no evidence to support value of hip sonography addressing its isolated presence without other signs.

References:

1. Holen KJ, Tegnander A, Bredland T et al. Universal or selective screening of the neonatal hip using ultrasound? *J Bone Joint Surg Br.* 2002; 84-B:886-890
2. Rosendahl K, Markestad T, Lie RT. Ultrasound screening for developmental dysplasia of the hip in the neonate: the effect on treatment rate and prevalence of late cases. *Pediatrics* 1994;94:47-52

What is the Optimal Imaging of Osteonecrosis, Perthes, and Bone Infarcts?
Diego Jaramillo, MD, MPH

17. *Regarding osteonecrosis of the proximal femur, the following are true EXCEPT:*

- A. Involvement is primarily anterior.
- B. Collapse can occur when more than 25% of the head is affected by avascular necrosis.
- C. Depression and irregularity of the articular surface leads to osteoarthritis.
- D. The metaphysis is more involved than the epiphysis.**
- E. In younger boys it is often idiopathic.

Rationale

Option A. Involvement of the femoral head in osteonecrosis is primarily anterior. Hence the importance of acquiring sagittal images [1], as coronal images may only depict the abnormality tangentially on the most anterior sections.

Option B. The greater the degree of involvement, the greater the likelihood of collapse.

Option C. Osteoarthritis occurs primarily because the collapse of the articular cartilage makes the articular surface irregular.

Option D. Although Legg-Calvé-Perthes can have some metaphyseal involvement, the abnormality is overwhelmingly epiphyseal. **D is false.**

Option E. Legg-Calvé-Perthes occurs predominantly in boys between 5 and 10 years of age.

Reference

1. Ha AS, Wells L, Jaramillo D (2008) Importance of sagittal MR imaging in nontraumatic femoral head osteonecrosis in children. *Pediatric Radiology* 38:1195-1200.

Impact of Obesity in the Diagnosis of SCFE and Knee Problems in Obese Children
Ricardo Restrepo, MD

18. *Which of the following statements regarding SCFE is true:*

- a. SCFE is the most common hip disorder affecting adolescents**
- b. SCFE is more common in whites than Hispanic patients
- c. The incidence of SCFE is the same for boys and girls
- d. Obesity is not a risk factor for SCFE
- e. SCFE occurs after a single acute traumatic event

Rationale

SCFE is the most common hip disorder in adolescence. The overall incidence rate for SCFE has been reported as 10.8/100,000 children. It is more common in boys with an incidence of 13.35 compared to 8.07 in girls. Normalized incident rates demonstrated that SCFE was almost 4 times (3.94) as prevalent in blacks and 2.53 times as prevalent in

Hispanics when compared with incidence rates in whites. Obesity is a well known risk factor. There are several types of SCFE: acute, chronic and acute on chronic. Chronic SCFE comprise 85% of the cases with symptoms for more than 3 weeks.

References:

1. Mannoff EM, Banffy MB et al (2005) Relationship between body mass index and slipped capital femoral epiphysis. J Pediatr Orthop 25: 744-46.
2. Lehmann C, Arons R et al (2006) The epidemiology of slipped capital femoral epiphysis: an updated. J Pediatr Orthop 26: 286 -90.

19. The following is “not” a risk factors for avascular necrosis of the femoral head after SCFE:

- a. Increased number of screws used to transfix the epiphysis
- b. Supero-lateral position of the screw tip in the femoral head
- c. Slip reduction.
- d. Sex and age of the patient.**
- e. Unstable SCFE.

Rationale:

There are no studies linking sex or age of the patient with the risk of SCFE. The other options have an increased risk of avascular necrosis.

References:

1. Staatz G, Honnef D et al (2007) Evaluation of femoral head vascularization in slipped capital femoral epiphysis before and after cannulated screw fixation with use of contrast-enhanced MRI: initial results. Eur Radiol 17: 163-68

20. Regarding the imaging of SCFE, which of the following statements is true:

- a. Frontal radiograph of the hips is the most accurate exam.
- b. On bone scan, the affected hip is always cold.
- c. On MRI synovitis is an early, “pre-slip” sign.**
- d. Frog leg radiograph is the most accurate exam to evaluate slip severity.
- e. Follow up radiographs are needed for 5 years after the femoral head slip.

Rationale:

Synovitis, epiphyseal widening and bone marrow edema are common findings seen in the “pre-slip’ SCFE. It is important to recognize these finding in a teenage patient as possible early signs of SCFE for early treatment before frank slippage occurs. Frog leg radiograph is more accurate in diagnosing SCFE. However, MRI is more accurate in diagnosing slip severity due to the 3-D capabilities. On bone scans, SCFE may present as increased or normal uptake in the affected hip.

References

1. Tins B, Cassar-Pullicino V et al (2008) The role of pre-treatment MRI in established cases of slipped capital femoral epiphysis. Eur J Radiol. In press.
2. Umans H, libeling MS et al (1998) Slipped capital femoral epiphysis: a physeal lesion diagnosed by MRI, with radiographic and CT correlation. Skeletal Radiol 27:139-144.
3. Lalaji A, Umans H et al (2002) MRI features of confirmed "pre-slip" capital femoral epiphysis: a report of two cases. Skeletal Radiol 31:362-365.
4. Strange-Vognsen H, Wagner A et al (1999) The value of scintigraphy in hips with slipped capital femoral epiphysis and the value of radiography and MRI after 10 years. Acta Orthopaedica Belgica 65: 33-38.

How Should We Image Skeletal Injuries in Child Abuse?

Rick R. Van Rijn, MD, PhD

21. A one year old boy is brought to the emergency department in the early morning. According to his parents he was well when they put him to bed and they found him face down deceased in his bed. The attending physician asks for your advice regarding imaging. Which imaging, if any, would you suggest to perform in this case?

- A. No imaging
- B. Skeletal survey**
- C. Whole body CT
- D. Whole body MRI

Rationale

Answer is B. Although 'SIDS' could be the final diagnosis, this is a diagnosis by exclusion. One of the main differential diagnoses should be child abuse. The ACR guideline should be followed in all cases of suspected child abuse.

Option A is not correct. In order to exclude child abuse additional imaging is mandatory.

Option C is not correct. Even though we know from trauma studies that CT outperforms CR with respect to rib fractures we don't know the sensitivity and specificity for metaphyseal corner fractures.

Option D is not correct. The use of whole body MRI in the field of child abuse is still in the experimental phase. Although it may seem to be a nice alternative to the skeletal survey; there is no evidence regarding the sensitivity and specificity for occult fractures.

References

1. American College of Radiology (ACR). ACR practice guideline for skeletal surveys in children. www.acr.org. Date accessed: 17-6-0008.
2. Renton J, Kincaid S, Ehrlich PF. Should helical CT scanning of the thoracic cavity replace the conventional chest x-ray as a primary assessment tool in pediatric trauma? An efficacy and cost analysis. J Pediatr Surg 2003 May;38(5):793-7.

3. Evangelista P, Barron C, Goldberg A, Jenny C, Tung G. MRI STIR for the Evaluation of Nonaccidental Trauma in Children. 2006.

NEUROIMAGING OF COMMON PEDIATRIC CONDITIONS

Imaging of Non-Accidental Head Injury?

Yutaka Sato, MD

22. Mixed-density subdural hematoma (SDH) on CT can be seen in:

- A. Acute hemorrhage in the chronic SDH.
- B. Acute SDH mixed with CSF leakage through arachnoid tear.
- C. Mixture of subdural hygroma and hematoma.
- D. Hyperacute SDH with clotted and unclotted blood.
- E. All of the above.**

The correct answer is E.

Rationale: Mixed density SDH is more commonly seen in SDH in NAHI and traditionally considered “acute hemorrhage in the chronic hematoma”, i.e., evidence of repeated injury, i.e. NAHI. However, there is increasing realization that mixed-density SDH may develop acutely within 24 hours after the injury. Some explanations of this phenomenon include situations in answers A, B, C, and D.

References

1. Hymel KP, Jenny C, Block RW. Intracranial hemorrhage and rebleeding in suspected victims of abusive head trauma: Addressing the forensic controversies. *Child Maltreat.* 2002;7(4):329-348
2. Tung GA, Kumar M, Richardson RC, Jenny C, Brown WD. Comparison of accidental and nonaccidental traumatic head injury in children on noncontrast computed tomography. *Pediatrics.* 2006;118(2):626-633.

Imaging Strategies for New Onset Seizures

Timothy N. Booth, MD

23. Select the false statement concerning evaluation of new onset seizures in children.

- A. MRI increased T2 signal and restricted diffusion within the hippocampus seen with febrile seizures is associated with subsequent mesial temporal sclerosis.
- B. Febrile seizures occur typically affect children between the ages of 6 and 60 months with fevers exceeding 102 deg.
- C. Gadolinium administration is not uniformly needed to evaluate focal seizures in a child at MR imaging.
- D. Children with infantile spasms usually have normal imaging evaluations.**

- E. Benign rolandic seizures, benign occipital epilepsy, and juvenile myoclonic seizures typically do not require imaging.

Rationales

Option A is true. Prolonged febrile seizures are associated with the abnormal MR findings as described. The children are associated with subsequent development of structural abnormalities of the limbic system, including mesial temporal sclerosis.

Option B is true. Simple febrile seizures are brief, generalized seizures that occur once in a 24 hour period. They occur between the ages of 6 months and 5 years and are associated with high fever.

Option C is true. A recent paper has found little use in the administration of gadolinium in children presenting for seizure evaluation who are under 2 years of age.

Option D is false. Children with infantile spasms commonly have significant neurologic impairment and abnormal imaging studies. Up to 25% of children with infantile spasms are diagnosed with tuberous sclerosis.

Option E is true. The listed seizure syndromes have few if any abnormalities detected on routine imaging studies and are diagnosed using clinical evaluation and typical EEG findings.

References

1. Provenzale JM et al. (2007) Hippocampal MRI Signal Hyperintensity after Febrile Status Epilepticus is Predictive of Subsequent Mesial Temporal Sclerosis. *AJR* 190: 976-983
2. Natsume J et al. (2007) Hippocampal Volumes and Diffusion-Weighted Image Findings in Children with Prolonged Febrile Seizures. *Acta Neurol Scand* 115: 25-28
3. Steering Committee on Quality Improvement and Management, Subcommittee on Febrile Seizures (2008) Febrile Seizures: Clinical Practice Guideline for the Long-term Management of the Child with Simple Febrile Seizures. *Pediatrics* 121: 1281-1286
4. Petrou M et al. (2007) Added Utility of Gadolinium in the Magnetic Resonance Imaging (MRI) Workup of Seizures in Children Younger Than 2 Years. *J Child Neurol* 22: 200-203
5. Strain JD et al. (2006) American College of Radiology Appropriateness Criteria, Seizures - Child.

Spinal Dysraphism: Categorizing Risk to Optimize Imaging

L. Santiago Medina, MD

24. *In patients at high risk of underlying spinal dysraphism such as high anorectal malformation and cloacal extrophy, what is the BEST imaging strategy?*

- A. Ultrasound alone
- B. Plain films alone
- C. Ultrasound and MRI
- D. MRI alone**
- E. Plain films and MRI

Correct answer is D – MRI alone. MRI is the best strategy for high risk patients suspected of having spinal dysraphism because of the high pretest probability of an underlying lesion. The rest of the strategies mentioned above are less optimal.

Reference

1. Newborns With Suspected Occult **Spinal Dysraphism**: A Cost-Effectiveness Analysis of Diagnostic Strategies, **L. Santiago Medina, MD, MPH***, **Kerry Crone, MD[†]** and **Karen M. Kuntz, ScD[‡]** PEDIATRICS Vol. 108 No. 6 December 2001, pp. e101

Role of Imaging in Scoliosis?

Geetika Khanna, MBBS

25. *Which of the following is NOT an indication for further evaluation with CT/MRI of a child presenting with scoliosis?*

- A. Rapid progression of curve ($>1^\circ$ per month)
- B. Absent gag reflex
- C. Age of onset between 8 – 10 years
- D. Left thoracic curve**
- E. Back pain especially at night

Rationale

Answer is D. A left thoracic curve alone has shown not to be a significant risk factor for an abnormal MRI.

Option A is not correct. Rapidly progressing curves have been shown to have a higher prevalence of underlying neural axis abnormalities such as syringomyelia. The strongest predictor for an abnormal MRI is an abnormal neurologic exam (absent gag reflex, abnormal deep tendon reflexes, or asymmetric superficial abdominal reflex) combined with a severe curve in a skeletally immature child. The prevalence of abnormal MRI in children with early onset curves (before age of 11 years) has been reported around 25%. *Hence, options B and C are not correct.*

Option E is not correct. Though children with scoliosis may complain of a dull back ache, the presence of severe pain especially at night, or function disturbing back pain should raise suspicion for an underlying pathology such as osteoid osteoma.

References

1. Evans SC, Edgar MA, Hall-Craggs MA, Powell MP, Taylor BA, Noordeen HH. MRI of 'idiopathic' juvenile scoliosis. A prospective study. *J Bone Joint Surg Br* 1996; 78:314-317.
2. Dobbs MB, Lenke LG, Szymanski DA, et al. Prevalence of neural axis abnormalities in patients with infantile idiopathic scoliosis. *J Bone Joint Surg Am* 2002; 84-A:2230-2234.
3. Taylor LJ. Painful scoliosis: a need for further investigation. *Br Med J (Clin Res Ed)* 1986; 292:120-122.
4. Morcuende JA, Dolan LA, Vazquez JD, Jirasirakul A, Weinstein SL. A prognostic model for the presence of neurogenic lesions in atypical idiopathic scoliosis. *Spine* 2004; 29:51-58.
5. Mejia EA, Hennrikus WL, Schwend RM, Emans JB. A prospective evaluation of idiopathic left thoracic scoliosis with magnetic resonance imaging. *J Pediatr Orthop* 1996; 16:354-358.