SPR 2012 Postgraduate Course
Diagnostic Pediatric Imaging in 2012: Bridging Horizons; Connecting Past, Present, and Future

Brian D. Coley, MD, and Edward Y. Lee, MD, MPH, Course Directors

Thoracic Imaging: From Interstitium to Airways

Richard I. Markowitz, MD and Beverley Newman, MD, FACR, Moderators

Interstitial Lung Disease in Infants: New Classifications, Imaging Findings, and Pathological Correlation

Edward Y. Lee, MD, MPH

You are shown an image from a HRCT (lung window) of a 1-month-old boy with persistent tachypnea, retractions, hypoxemia, and crackles. Which one of the following is the MOST likely diagnosis of this condition?

A. Acinar dysplasia
B. Trisomy 21
C. ABCA3 genetic mutation
D. Neuroendocrine cell hyperplasia of infancy (NEHI)
E. Pulmonary interstitial glycogenosis (PIG)

Answer: D

REFERENCES:

1. Guillerman RP, Brody AS. Contemporary perspective on pediatric diffuse lung disease. Radiol Clin North Am. 2011; 49(5): 847 – 868.
2. Brody AS. New perspective in imaging interstitial lung disease in children. Pediatr Radiol. 2008; 38 Suppl 2: S205 – 207.
3. Brody AS, Guillerman RP, hay TC, et al. Neuroendocrine cell hyperplasia of infancy: diagnosis with high-resolution CT. AJR Am J Roentgenol. 2010; 194(1): 238 – 244.

Large Airway Disease in Pediatric Patients: Impact of Advanced Post-processing Techniques
Catherine M Owens, BSc MBBS MRCP FRCR

Which one of following information regarding multiplanar reconstructions (MPRS) with MDCT for evaluation of large airways in pediatric patients is correct?

A. MPRS is less accurate than axial images
B. MPRS is impressive but does not provide additional information
C. MPRS is impressive but often provide misleading information
D. MPRS is as accurate as axial images and may provide additional information

Answer: D

REFERENCES:

1. Heyer C M, Kagel T, Lemburg S P, Nicolas V, Rieger C H. Evaluation of tracheobronchial anomalies in children using low-dose multidetector CT: report of a 13-year-old boy with a tracheal bronchus and recurrent pulmonary infections. *Pediatr.Pulmonol.* 2004; **38:** 168-173.
2. Siegel M J. Multiplanar and three-dimensional multi-detector row CT of thoracic vessels and airways in the pediatric population. *Radiology* 2003; **229:** 641-650.
   Salvolini L, Bichi S E, Costarelli L, De Nicola M. Clinical applications of 2D and 3D CT imaging of the airways--a review. *Eur.J.Radiol.* 2000; **34:** 9-25.
4. Lee EY Siegel MJ MDCT of the tracheo bronchial tree in Pediatric patients Journal of Thoracic Imaging.22(3);300-309. August 2007

Pediatric Thoracic Neoplasms: Review and Updates
Sue C. Kaste, DO

A 14 year-old boy from Nevada complains of cough and fevers while visiting relatives in Montana. A chest x-ray is obtained which shows a large non-calcified anterior mediastinal mass. Which of the differential diagnoses listed below is most likely?

A. Hodgkin's disease
B. Non-Hodgkin's lymphoma
C. Histoplasmosis
D. Thymic hyperplasia
E. Ganglioneuroblastoma

Answer: A

a. Lymphoma is the most common cause of pediatric mediastinal masses and is the third most common malignancy in children and adolescents in the United States. About 60% are non-Hodgkin's and 40% Hodgkin's disease. About two-thirds of patients with Hodgkin's disease and half of those with non-Hodgkin's lymphoma present with anterior mediastinal adenopathy. Thus, most anterior mediastinal masses represent Hodgkin's disease. [References: Franco A, Modu NS, Meza MP. Imaging evaluation of pediatric mediastinal

masses. Radiol Clin North Am 2005; 43(2):325-53b. McCarville MB. Malignant pulmonary and mediastinal tumors in children: differential diagnoses. Cancer Imaging 2010; 10, S35-S41.]

b. Non-Hodgkin lymphoma less commonly presents with a mediastinal mass as described in answer a.
c. Histoplasmosis may be difficult to differentiate from lymphoma. Consideration of the region in which the patient lives or has visited, the presence of calcifications with the nodal masses, and the distribution of the adenopathy can help distinguish between histoplasmosis and lymphoma. The patient lives and was visiting outside of the United States regions where *Histoplasma capsulatum* is endemic.
[Reference: Kirchner SG, Hernanz-Schulmam M, Stein SM, Wright PF, Heller RM. Imaging of pediatric mediastinal histoplasmosis. Radiographics 1991; 11:365-81.
d. Thymic hyperplasia is typically seen in infants and children, not in teenagers.
[Reference: Franco A, Modu NS, Meza MP. Imaging evaluation of pediatric mediastinal masses. Radiol Clin North Am 2005; 43(2):325-53]
e. Ganglioneuroblastoma is a neuroblastic tumor arising from primitive sympathetic neuronal cells and is develops in the posterior mediastinum, when in the chest.
[Reference: Lonergan GJ, Schwab CM, Suarez ES, Carlson CL. Radiographics 2002; 22:911-34]

MRI of Pediatric Lungs and Airways: Current Status and Future Direction
Talissa Altes, MD

Historically MRI of the lung has lagged behind MRI of other organ systems due to the intrinsic difficulties of imaging the lung. Which of the following factors make lung MRI difficult?

A. Low proton density
B. Numerous air-tissue interfaces which create an inhomogeneous magnetic environment and lead to a very lowT_2^* value (on the order of 1 ms at 1.5T)
C. Cardiac and respiratory motion
D. All of the above

Answer: D

As compared with solid organs, the physical density of the lung and thus the proton density of the lung is about 3 orders of magnitude lower. The lower proton density results in a lower signal generated by the lung. Thus answer A is correct. The lung contains numerous air-tissue interfaces, and these interfaces create magnetic susceptibility effects, which cause what little signal is generated in the lung to rapidly decay. Thus answer B is also correct. Cardiac motion can create artifacts in MR images of the lung. Lung MR imaging has to be fast enough to be performed in a breath hold or some method for correcting for respiratory motion employed to obtain motion free images. Thus, answer C is also correct making the best choice answer D.

References:

1. Ohno Y, Koyama H, Yoshikawa T, et al. Pulmonary magnetic resonance imaging for airway diseases. J Thorac Imaging. 2011; 26(4): 301 – 316.
2. Lee EY. Advancing CT and MR imaging of the lungs and airways in children: imaging into practice. Pediatr Radiol. 2008; 38 Suppl 2: S208 – S212.

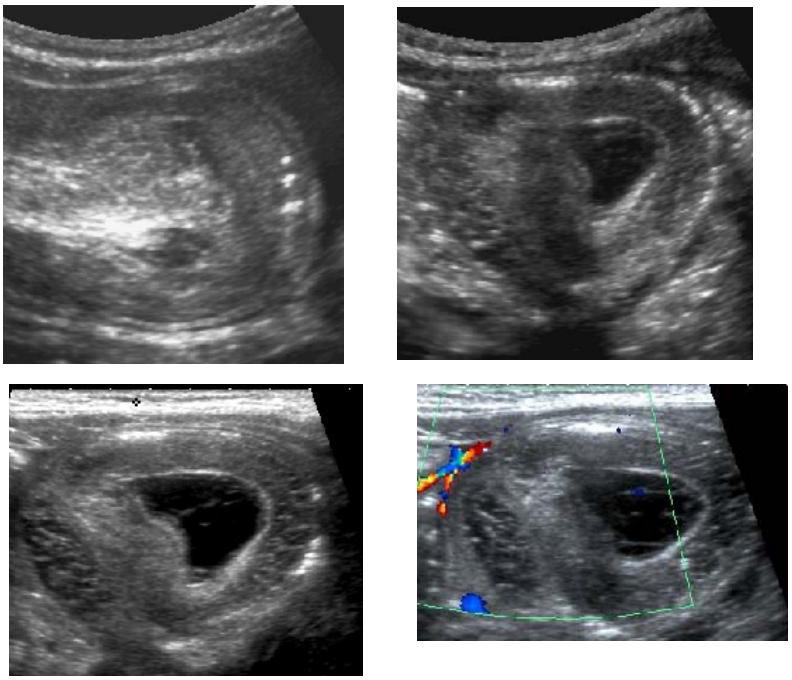
Abdominal Imaging: From Asking to Answers

David K. Yousefzadeh, MD and William H. McAlister, MD, Moderators

Bowel Sounds and Music: Malrotation, Intussusception, Appendicitis, Inflammatory Bowel Disease, Imperforate Anus

Laurent A. Garel, MD

The following sonogram was performed in a 9-month-old female presenting in the ER with abdominal pain and rectal bleeding.



What is the MOST likely conclusion regarding the sonographic features?

A. Classic intussusception with 95% success rate of pneumatic reduction.
B. Intussusception with an underlying lead point.
C. Intussusception with a slight increased failure rate of pneumatic reduction.
D. Intussusception with non-viable bowel (bowel necrosis).

Answer: D

REFERENCES
1. Britton I, Graham Wilkinson A. Ultrasound features of intussusception predicting outcome of air enema. Pediatr Radiol 1999;29:705-710.
2. del-Pozo G, González-Spinola J, Gómez-Ansón B et al. Intussusception: Trapped peritoneal fluid detected with US – Relationship to reducibility and ischemia. Radiology 1996;201:379-383.
3. Gartner RD, Levin TL, Borenstein SH et al. Interloop fluid in intussusception: what is its significance? Pediatr Radiol 2011;41:727-731.
4. Stranzinger E, DiPietro MA, Yarram S et al. Intramural and subserosal echogenic foci on US in large-bowel intussusceptions: prognostic indicator for reducibility? Pediatr Radiol 2009;39:42-46.
5. Lim HK, Bae SH, Lee KH et al. Assessment of reducibility of ileocolic intussusception in children: usefulness of color Doppler sonography. Radiology 1994;191:781-785.
6. Lam AH, Firman K. Value of US including color Doppler in the diagnosis and management of longstanding intussusception. Pediatr Radiol 1992;22-112-114.

RATIONALE
Sonography demonstrates an ileocolic intussusception, with interloop fluid, intramural and subserosal echogenic foci (air), and lack of perfusion at color Doppler ultrasound.
Option A is not correct. All the aforementioned features are predictors of bowel ischemia, lack of pneumatic reduction, and increased risk of bowel perforation.
Option B is also irrelevant, for the sonogram does not display an intestinal duplication, a polyp or a Meckel diverticulum, the most frequent intussusception lead points.
Option C is true with regard to the interloop fluid which is an indicator of a less successful reduction rate. However the association of interloop fluid, intramural air and quasi-absence of blood flow within the intussusceptum and the intussuscipiens is very suggestive of bowel necrosis and non-reducibility. The risk of perforation following a reduction attempt is then maximum. Most surgeons will favour a primary operative management in such circumstances.

Update on MDCT and MRI of Hepatobiliary Disease in Children: What's New
Lisa H. Lowe, MD

6-week-female presents with skin lesions. Based on the images shown, which of the following would be the most appropriate initial treatment?

A. Sclerotherapy
B. Catheter embolization
C. Liver transplant
D. Medical therapy

Answer: D

REFERENCES:
1. Restrepo R, Palani R, Cervantes LF, Duarte AM, Amjad I, Altman NR. Hemangiomas revisited: the useful, the unusal and the new. Part 1: overview and clinical and imaging charachteristics. *Pediatr Radiol 2011*; 41(7): 895-904

2. Restrepo R, Palani R, Cervantes LF, Duarte AM, Amjad I, Altman NR. Hemangiomas revisited: the useful, the unusal and the new. Part 2: endangering hemangiomas and treatment. *Pediatr Radiol* 2011; 41(7): 905-915
3. Burrows PE, Dubois J, Kassarjian A. Pediatric hepatic vascular anomalies. *Pediatr Radiol* 31:533-545, 2001
4. Mulliken JB. A biologic approach to cutaneous vascular anomalies. *Pediatr Dermatol* 9:356-357, 1992

RATIONALE:
The correct answer is "Medical therapy". This is a case of multiple infantile hemangiomas on the skin and in the liver. The imaging findings are classic including numerous well defined hepatic lesions of variable size on sonography, which enhance peripherally after contrast administration. The learner must recognize the diagnosis shown in order to choose the most appropriate initial treatment. The initial treatments for numerous infantile hemangiomas are watchful waiting and medical therapy, including administration of anti-angiogenic drugs such as steroids and propanolol. Watchful waiting was intentionally NOT included among the choices.

The other choices listed are not used to treat infantile hemangiomas at all, or are only considered in extreme circumstances after other methods have failed.

Specifically, sclerotherapy is an initial treatment for venolymphatic malformations.

Catheter embolization is an initial treatment for arteriovenous malformations.

Liver transplant is rarely considered an option for infantile hemangiomas after other methods have failed.

Diagnostic Errors in Pediatric Abdominal Imaging: Diagnostic Pearls and Pitfalls
George A. Taylor, MD

You are shown a pelvic CT scan in an 8- year-old afebrile girl with abdominal pain and vomiting. The appendix is clearly seen and measures 7 mm in greatest transverse dimension. No other imaging abnormalities are present. The appendix is called abnormal based on size criteria. At pathologic examination, the appendix is normal. What type of cognitive bias is most likely at work in this case of overinterpretation?

A. Anchoring heuristic (premature closure)
B. Availability heuristic (memory of a similar case)
C. Framing effect (how data are presented)
D. Blind obedience (reluctance to confront authority)

Answer: D

This error represents "blind obedience" to size criteria available in the literature, where the normal appendix is less than 7 mm in transverse diameter. In the absence of other signs of primary or secondary inflammation, the likelihood of appendicitis is very low. An isolated CT finding of an enlarged appendix is not sufficient for the diagnosis of appendicitis on CT.

Option A is not correct. Anchoring heuristic relates to an erroneous diagnosis in which other possible pathologic diagnoses are not considered.
Option B is not correct. The availability heuristic would most often be invoked when an unusual diagnosis is considered more likely than a common diagnosis because of a recently experienced case.
Option C is not correct. The framing effect would have been at work here if the patient had been febrile with an elevated WBC count more strongly suggestive of appendicitis.

References:

1. Taylor GA, Callahan MJ, Rodriguez DP, Smink D. CT for Suspected Appendicitis in Children: An Analysis of Diagnostic Errors Pediatr Radiol 2006;36:331-337
2. Kassirer JP, Kopelman RI. Cognitive errors in diagnosis: instantiation, classification, and consequences. Am J Med 1989; 86:433-441.
3. Bordage G. Why did I miss the diagnosis? Some cognitive explanations and educational implications. Acad Med 1999;74: S138-S143.
4. Croskerry P. The importance of cognitive errors in diagnosis and strategies to minimize them. Acad Med 2003; 78:775-780.
5. Taylor GA, Voss SD, Melvin PR, Graham DA. Diagnostic errors in pediatric radiology. Pediatr Radiol 2011;41:327-334 published online September, 2010 DOI 10.1007/s00247-010-1812-6

Neonatal Congenital Abdominal Masses: Clues to Reach a Diagnosis
Marta Hernanz-Schulman, MD, FAAP, FACR

Which of the following renal tumors is associated with the worst prognosis?

A. Classic type CMN
B. Ossifying renal tumor of infancy
C. Rhabdoid tumor
D. Sclerosing nephrogenic rests
E. Congenital Wilms

Answer: C

REFERENCES:

1. Chan HS, Cheng MY, Mancer K. et al. Congenital mesoblastic nephroma. A clinicoradiologic study of 17 cases representing the pathologic spectrum of the disease. J Pediatr 1987;111:64-70
2. Lowe LH, Isuani BH, Heller RM, Stein SM, Hernanz-Schulman M. Pediatric renal masses: Wilms tumor and beyond. Radiographics 2000;20:1585-1603
3. Sotelo-Avila C, Beckwith JB, Johnson JE. Ossifying renal tumor of infancy. A clinicopathologic study of nine cases. Pediatr Pathol Lab Med 1995;15:745-762
4. Lonergan GJ, Martinez-Leon MI, Agrons GA, et al. Nephrogenic rests, Nephroblastomatosis and associated lesions of the kidney. Radiographics 1998; 18:947-968
5. Agrons GA, Kingsman KD, Wagner BJ, Sotelo-Avila C. Rhabdoid tumor of the kidney in children: a comparative study. AJR 1997;168:447-451

RATIONALE:
The correct answer is rhabdoid tumor. This is a highly aggressive tumor with very poor prognosis, and presenting symptoms may be those of advanced metastatic disease. In addition to metastatic disease, this tumor is also associated with additional, primary brain tuors, usually midline, including PNEt, ependymoma, cerebellar and brainstem astrocytomas

Classic type CMN is usually cured with resection alone; metastatic disease is rare, and ore often seen with the more aggressive, cellular type.

Ossifying renal tumor of infancy is a benign condition, which may be confused with renal stones or staghorn calculi.

Sclerosing nephrogenic rests are microscopic disease and considered benign. Hyperplastic and neoplastic rests are associated with development of Wilms

Pediatric Procedures: From Imaging to Intervention
James S. Donaldson MD and Neil D. Johnson, MBBS, Moderators

The Spectrum of Vascular Anomalies in Pediatric Patients: Multimodality Imaging Evaluation and Current Treatment
Patricia E. Burrows, MD

A six-month-old boy presents with a blue soft tissue mass involving his neck. The lesion is flat at rest but protrudes when he cries. MRI shows a focal mass that is hyperintense on STIR sequence, contains signal voids and enhances inhomogeneously. Which of the following represents appropriate treatment for this mass?

A. Propranolol 2 mg per day for six months.
B. Percutaneous sclerotherapy using doxycycline.
C. Percutaneous sclerotherapy using sodium tetradecyl sulfate foam.
D. Angiography and arterial embolization.

Answer: C

References:

1. Legiehn, G.M. and M.K. Heran, A Step-by-Step Practical Approach to Imaging Diagnosis and Interventional Radiologic Therapy in Vascular Malformations. Semin Intervent Radiol, 2010. **27**(2): p. 209-31.
2. Choi DJ, Alomari AI, Chaudry G, Orbach DB. Neurointerventional management of low-flow vascular malformations of the head and neck. Neuroimaging clinics of North America 2009; 19:199-218

Vascular Interventional Procedures in Children: Tips to Optimal Management
Manraj Heran, MD

Which one of the following is the correct statement regarding trauma in pediatric patients?

A. Trauma is the leading cause of death in children > 1 year of age
B. Penetrating trauma accounts for the majority of injuries
C. Vascular injuries are over diagnosed
D. Pediatric patients with combined splenic and hepatic injury have a mortality of 20-30%

Answer: A

REFERENCES:

1. Guice KS, Cassidy LD, Oldham KT. Traumatic injury and children: a national assessment. *J Trauma*. Dec 2007;63(6 Suppl):S68-80; discussion S81-6.
2. Wang MY, Hoh DJ, Leary SP, Griffith P, McComb JG. High rates of neurological improvement following severe traumatic pediatric spinal cord injury. *Spine*. Jul 1 2004;29(13):1493-7; discussion E266. [Medline].
3. Achildi O, Betz RR, Grewal H. Lapbelt injuries and the seatbelt syndrome in pediatric spinal cord injury. *J Spinal Cord Med*. 2007;30 Suppl 1:S21-4. [Medline]. [Full Text].
4. Cigdem MK, Onen A, Siga M, Otcu S. Selective nonoperative management of penetrating abdominal injuries in children. *J Trauma*. Dec 2009;67(6):1284-6; discussion 1287. [Medline].
5. Cloutier DR, Baird TB, Gormley P, McCarten KM, Bussey JG, Luks FI. Pediatric splenic injuries with a contrast blush: successful nonoperative management without angiography and embolization. *J Pediatr Surg*. Jun 2004;39(6):969-71.
6. Rogers CG, Knight V, MacUra KJ, Ziegfeld S, Paidas CN, Mathews RI. High-grade renal injuries in children--is conservative management possible?. *Urology*. Sep 2004;64(3):574-9. [Medline].
7. Knight JC, Nazim M, Riggs D, Channel J, Mullet C, Vaughan R, et al. Is the broselow tape a reliable indicator for use in all pediatric trauma patients?: a look at a rural trauma center. *Pediatr Emerg Care*. Jun 2011;27(6):479-82. [Medline].
8. Buccimazza I, Thomson SR, Anderson F, Naidoo NM, Clarke DL. Isolated main pancreatic duct injuries spectrum and management. *Am J Surg*. Apr 2006;191(4):448-52. [Medline].
9. Buckley JC, McAninch JW. The diagnosis, management, and outcomes of pediatric renal injuries. *Urol Clin North Am*. Feb 2006;33(1):33-40, vi. [Medline].
10. Claret Teruel G, Palomeque Rico A, Cambra Lasaosa FJ, Catala Temprano A, Noguera Julian A, Costa Clara JM. Severe head injury among children: computed tomography evaluation as a prognostic factor. *J Pediatr Surg*. Nov

Non-vascular Interventional Procedures in Pediatric Patients: What is New?
Joao G. Amaral, MD

All these of the following procedures can now be performed under "real time" Magnetic Resonance Guidance, EXCEPT:

a. High Focused Ultrasound ablation of uterine leiomyomas
b. Soft tissue, brain and bone biopsies
c. Cryoablation of renal tumors
d. Intra-articular (hips, temporo-mandibular joints, facet joints) injections
e. Vascular procedures with standard (metallic or nitinol) guidewires

Answer: E

Rationale:
Regular guidewires cannot be used in the MR because standard guidewires with a stainless steel core may be drawn into the magnet and nitinol guidewires may lead to rapid heating during MR sequences. In vitro experiments with standard nitinol guidewires, which are not ferromegnatic but electrical conductors, showed substantial heating around the guidewire tips. The degree of heating is proportional to the power of the radiofrequency pulse. It also varies between different sequences and changes with the flip angle.

References:

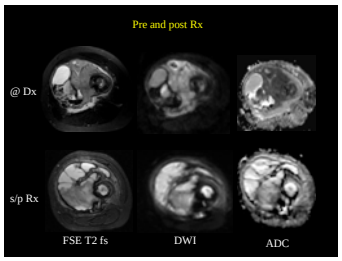
1. Eur Radiol. 2008 Apr;18(4):645-57. Epub 2007 Dec 11. MR-guided endovascular interventions: a comprehensive review on techniques and applications. Kos S, Huegli R, Bongartz GM, Jacob AL, Bilecen D.
2. AJR Am J Roentgenol. 2010 Jan;194(1):274-80. Leiomyoma shrinkage after MRI-guided focused ultrasound treatment: report of 80 patients. LeBlang SD, Hoctor K, Steinberg FL.
3. J Magn Reson Imaging. 2008 May;27(5):1181-7. MR-guided core biopsy with MR fluoroscopy using a short, wide-bore 1.5-Tesla scanner: feasibility and initial results. Stattaus J, Maderwald S, Forsting M, Barkhausen J, Ladd ME.
4. Cardiovasc Intervent Radiol. 2011 Feb;34(1):188-92. Epub 2010 Mar 27. MR-guided freehand biopsy of liver lesions with fast continuous imaging using a 1.0-T open MRI scanner: experience in 50 patients. Fischbach F, Bunke J, Thormann M, Gaffke G, Jungnickel K, Smink J, Ricke J.
5. Neurosurgery. 2006 Apr;58(4 Suppl 2):ONS-338-45. Intraoperative magnetic resonance imaging-guided neurosurgery at 3-T. Truwit CL, Hall WA.
6. Eur J Radiol. 2006 Aug;59(2):198-202. Epub 2006 May 23. MRI-guided percutaneous cryoablation of renal tumors: use of external manual displacement of adjacent bowel loops. Tuncali K, Morrison PR, Tatli S, Silverman SG.
7. J Magn Reson Imaging. 2008 Aug;28(2):462-5. MR-guided direct arthrography of the hip. Graves MJ, Wakely S, Bearcroft PW, Black RT, van Rooyen E, Soh E, Lomas DJ.
8. AJR Am J Roentgenol. 2009 Apr;192(4):W161-7. Freehand real-time MRI-guided lumbar spinal injection procedures at 1.5 T: feasibility, accuracy, and safety. Fritz J,

Thomas C, Clasen S, Claussen CD, Lewin JS, Pereira PL.
9. AJR Am J Roentgenol. 2009 Oct;193(4):1148-54. MRI-guided injection procedures of the temporomandibular joints in children and adults: technique, accuracy, and safety. Fritz J, Thomas C, Tzaribachev N, Horger MS, Claussen CD, Lewin JS, Pereira PL.

Musculoskeletal Imaging: From Planning to Performance
Paul S. Babyn, MD and Ricardo Restrepo, MD, Moderators

Imaging of Pediatric Bone and Soft Tissue Tumors: Techniques and Advances
Kirsten Ecklund MD

The images presented are of a 9 y.o. boy with distal femoral telangiectatic osteosarcoma. The top row is at diagnosis, bottom row after 2 cycles of chemotherapy. What do the post treatment images reveal?



A. No change
B. Tumor growth on therapy
C. Decrease in tumor size, response to therapy
D. Increase in tumor necrosis related to therapy

Answer: D

The post therapy scan shows an overall increase in tumor size. The DWI images show high signal which could represent restricted diffusion due to tumor progression. The ADC map, however, shows significantly higher ADC compared with the pre-therapy scan. This indicates increased diffusion. The high signal on the DWI images is T2 effect. In response to therapy, the tumor has undergone necrosis and resultant increase in size. The associated decrease in cellularity leads to increased diffusion. At resection, pathology revealed > 95% necrosis.

References:

1. Costa FM, Ferreira EC, Vianna EM. Diffusion-weighted magnetic resonance imaging for the evaluation of musculoskeletal tumors. Magn Reson Imaging Clin N Am. 2011 Feb;19(1):159-80.
2. Jaramillo D. Whole-body MR imaging, bone diffusion imaging: how and why?. Pediatr Radiol. 2010 Jun;40(6):978-84.

3. MacKenzie JD, Gonzalez L, Hernandez A, Ruppert K, Jaramillo D. Diffusion-weighted and diffusion tensor imaging for pediatric musculoskeletal disorders. Pediatr Radiol. 2007 Aug;37(8):781-8.

Imaging of Congenital and Developmental Abnormalities of Early Childhood
Tal Laor, MD

You are shown a radiograph of a child with a right congenital femoral anomaly. Which one of the following is correct?

A. The proximal femoral epiphysis is absent.
B. With growth, this child will likely develop a pseudarthrosis of the femoral neck and varus alignment of the proximal femur.
C. For maximal function in this child, a hip disarticulation should be performed.
D. Associated fibular anomalies are rare.

Answer: B.

References:

1. Anton, C.G., Applegate, K.E., Kuivila, T.E., Wilkes, D.C. (1999) Proximal femoral focal deficiency (PFFD): More than an abnormal hip. *Semin Musculoskelet Radiol* 3, 215-226.
2. Gillespie, R., Torode, I.P. (1983) Classification and management of congenital abnormalities of the femur. *J Bone Joint Surg Br* 65, 557-68.
3. Herring JA, Cummings DR. (1996) The limb deficient child. In: Morrissy RT, Weinstein SL. Lovell & Winter's Pediatric Orthopaedics, 4th ed. Philadelphia, PA, Lippincott-Raven Publishers, 1142-1149.
4. Laor, T., Burrows, P.E. (1998) Congenital anomalies and vascular birthmarks of the lower extremities. *Magn Reson Imaging Clin N Am* 6, 497-519.

Rationale:
This child has the mildest form of proximal femoral focal deficiency (PFFD) (Aitken type A). This form of PFFD is characterized by a relatively normal proximal femoral epiphysis and acetabulum, a pseudarthrosis of the femoral neck, and varus configuration of the subtrochanteric proximal femur. The pseudarthrosis usually heals by the time of skeletal maturity.

Option A is not correct. The radiograph shows a normal configuration of the right acetabulum. This indicates that a normal cartilaginous proximal femoral epiphysis is present.

Answer C is not correct. In a child with a proximal femoral epiphysis and a developed acetabulum, the hip can be relatively stable. The degree of leg length discrepancy is generally constant throughout growth. Patients with an ultimate length disparity of less than 20 cm, or less than 40%-60% of the contralateral normal side, might undergo limb lengthening. Occasionally, epiphysiodesis of the contralateral side can help to correct the discrepancy. More severe forms of PFFD may be managed with lower leg amputation, rotationplasty,

femur to pelvis and/or knee fusion, in addition to non-standard prostheses. Despite extensive associated abnormalities in even the most severe forms of PFFD, hip disarticulation is not a usual treatment.

Option D is not correct. Although percentages vary in the literature, there is up to an 80% association of PFFD with fibular hemimelia.

Multimodality Imaging of Skeletal Trauma in Children: Using All of the Tools
Peter J. Strouse, MD

Ultrasound would be most helpful for confirmation of which of the following fractures?

A. Triplane fracture of the distal tibia in a 14-year-old
B. Supracondylar fracture of the distal humerus in a 5-year-old
C. Tibial spine avulsion in a 10-year-old
D. Salter I fracture of the proximal humerus in a newborn
E. Toddler fracture of the tibial diaphysis in a 14-month-old

Answer: D

Option A is not correct. Triplane fractures are best seen by radiography and further delineated by computed tomography. Ultrasound is not used to diagnose or delineate triplane fractures.
Option B is not correct. Supracondylar fractures are diagnosed by radiography without the use of ultrasound.
Option C is not correct. Most tibial spine avulsion fractures are diagnosed by radiography. Computed tomography or MRI may also be used to make the diagnosis or delineate the fracture. Ultrasound is not useful in diagnosing tibial spine fractures.
Option E is not correct. Toddler fractures are diagnosed by radiography, not ultrasound.
Option D is correct. In a newborn, the proximal humeral epiphysis is usually not yet ossified. The cartilaginous humeral head is thus radiolucent and not seen on radiographs. Ultrasound is used to delineate the cartilaginous humeral head and its relationship to the proximal humeral metaphysis. Ultrasound will readily confirm Salter I fractures of the proximal humerus by showing discontinuity between the humeral epiphysis and metaphysis. While it is true that all fractures are potentially identified by ultrasound, sonography is of particular value in confirming displacement of the un-ossified epiphysis of the neonate.

References:

1. Fisher NA, Newman B, Lloyd J, Mimouni F. Ultrasongraphic evaluation of birth injury to the shoulder. J Perinatol 1995;15:398-400
2. Brown SD, Kasser JR, Zurakowski D, et al. Analysis of 51 tibial triplane fractures using CT with multiplanar reconstruction. AJR Am J Roentgenol 2004;183:1489-1495
3. John SD, Wherry R, Swischuk LE, et al. Improving detection of pediatric elbow fractures by understanding their mechanics. Radiographics 1996;16:1443-1460
4. John SD, Moorthy CS, Swischuk LD. Expanding the concept of the toddler's fracture. Radiographics 1997;17:367-376
5. Mosier SM, Stanitski CL. Acute tibial tubercle avulsion fractures. J Pediatr Orthop 2004;24:181-184

Cartilage Imaging: Indications and Techniques
Diego Jaramillo, MD, MPH

The following techniques only detect glycosaminominoglycan (GAG) loss:

A. T1 rho and diffusion
B. Ultrashort TE and diffusion
C. dGEMRIC and Na+
D. T2 and T1 rho
E. dGEMRIC and T2

Answer: C

dGEMRIC and Na are specific for detection of changes in GAG. dGEMRIC (delayed gadolinium enhanced MRI of cartilage) uses ionic negatively charged gadolinium which is repelled by the negatively charged GAG molecules. The concentration of gadolinium in the cartilage is inversely proportional to the concentration of GAG. Na+ ions are attracted to the negatively charged GAG molecules; the Na+ concentration as determined by Na imaging is directly proportional to the GAG concentration. T1rho is sensitive to GAG loss, but once GAGs are depleted it is influenced by collagen concentration. Ultrashort TE is not sensitive to GAG and T2 mapping reflects primarily collagen and water concentrations, although it does also reflect GAG concentration. References [1-4]

The most specific imaging sequence for evaluation of focal abnormalities within the cartilage is:

A. T1-weighted spin echo (SE)
B. T2- weighted spin echo (SE)
C. STIR
D. T1-weighted GRE
E. T2*-wieghted GRE

Answer: B

T2- weighted spin echo (SE) is sensitive to T2 relaxation in the tissue which in turn is a reflection of the amount of free water. Since in cartilage water is bound to glycosaminoglycans and collagen, and since the amount of both vary between the different cartilaginous regions, T2- weighted SE imaging depicts the zonal architecture of cartilage. Both normal ossification and cartilage destruction result in increase in free water, and thus increased T2 signal. STIR images have a similar contrast but usually less spatial resolution. T1 and T2* images do not show a substantial zonal differentiation between the cartilaginous regions as the cartilage is typically of almost uniform high signal intensity.
References [5, 6]

REFERENCES:

1. Choi JA, Gold GE (2011) MR imaging of articular cartilage physiology. Magn Reson Imaging Clin N Am 19:249-282.

2. Crema MD, Roemer FW, Marra MD, et al. (2011) Articular cartilage in the knee: current MR imaging techniques and applications in clinical practice and research. Radiographics 31:37-61.
3. Chen CA, Kijowski R, Shapiro LM, et al. (2010) Cartilage morphology at 3.0T: assessment of three-dimensional magnetic resonance imaging techniques. J Magn Reson Imaging 32:173-183.
4. Gold GE, Chen CA, Koo S, et al. (2009) Recent advances in MRI of articular cartilage. AJR Am J Roentgenol 193:628-638.
5. Laor T, Jaramillo D (2009) MR imaging insights into skeletal maturation: what is normal? Radiology 250:28-38.
6. Goodwin DW (2011) MRI appearance of normal articular cartilage. Magn Reson Imaging Clin N Am 19:215-227.

Tuesday, April 17, 2012

Neuroimaging: From "What" to "How"
Richard L. Robertson, MD and Yutaka Sato, MD, PhD, Moderators

Imaging of Stroke in Children: What do We Need to Know for Optimal Management?
Avrum N. Pollock, MD, FRCPC

All of the following etiologies are implicated as a cause of stroke in children, EXCEPT:

A. Factor V Leiden deficiency
B. Cardiac Lesions with right to left shift
C. Alpha Thalassemia
D. Moya Moya and its etiologies, such as Trisomy 21, NFI and Sickle Cell Disease, etc...
E. Trauma

Answer: C

REFERENCES

1. Adams RJ, Kutlar A, Mckie V, et al. Alpha Thalassemia and Stroke Risk in Sickle Cell Anemia. American Journal of Hematology 45:279-282 (1994)
2. Kenet G, Sadetski S, Murad H, et al. Factor V Leiden and Antiphospholipid Antibodies Are Significant Risk Factors for Ischemic Stroke in Children. Stroke 2000, 31:1283-1288
3. Furlan AJ. Patent Foramen Ovale and Recurrent Stroke: Closure is the Best Option: Yes. Stroke 2004, 35:803-804
4. Scott RM, Smith ER. Moya Moya Disease and Moyamoya Syndrome. N Engl J Med 2009; 360:1226-1237
5. Thanvi B, Munshi S, Robinson T. Carotid and vertebral artery dissection syndromes. Postgrad Med J. 2005 June; 81(956): 383-388

RATIONALE

Although alpha thalassemia can cause severe anemia and bony changes, it does not cause stroke. In fact, in the sickle cell population (SS disease), the association with alpha

thalassemia offers a degree of protection against stroke when compared with control sickle cell patients without associated alpha thalassemia.

Factor V Leiden deficiency is known to lead to venous thrombosis, but has also been implicated as a cause of stroke in children.

Cardiac lesions, such as patent foramen ovale (PFO) are known to lead to take off points for stroke, leading to embolic type infracts upstream from the cardiac defect.

Moya moya and it's many causes (however, often idiopathic in nature) predisposes the pediatric and adolescent patient to stroke.

Trauma, especially to the head and neck region, can lead to stroke, if the child sustains an arterial dissection, which can then act as a nidus for thrombus formation, and subsequent embolic phenomenon upstream along the respective vascular territories involved.

Advanced Imaging Techniques for Neuroimaging in Pediatric Patients: Where Are We Now?
Blaise V. Jones, MD

What has been the greatest clinical impact of the increased use of fMR in the pediatric population?

A. Increased diagnosis of autism spectrum disorders
B. Decreased use of wada testing
C. More accurate diagnosis of obsessive compulsive disorder
D. More accurate diagnosis of metabolic brain disease
E. More accurate diagnosis of dyslexia

Answer: B

The use of fMR has significantly decreased the need to rely on wada testing to localize language in children undergoing temporal and frontal lobe surgery. While there have been numerous publications on the use of fMR in research investigations of dyslexia, autism, and OCD, it is not a clinical tool used to make the diagnosis in these conditions. There may be a future role for fMR in the management of some metabolic brain diseases, but it has had no clinical impact on the diagnosis of these conditions.

1. Dupont S, Duron E, Samson S, Denos M, Volle E, Delmaire C, Navarro V, Chiras J, Lehéricy S, Samson Y, Baulac M. Functional MR imaging or Wada test: which is the better predictor of individual postoperative memory outcome? *Radiology*. 2010 Apr;255(1):128-34.
2. Kesavadas C, Thomas B, Sujesh S, Ashalata R, Abraham M, Gupta AK, Radhakrishnan K. Real-time functional MR imaging (fMRI) for presurgical evaluation of paediatric epilepsy. *Pediatr Radiol*. 2007 Oct;37(10):964-74.
3. Lai G, Schneider HD, Schwarzenberger JC, Hirsch J. Speech stimulation during functional MR imaging as a potential indicator of autism. *Radiology*. 2011 Aug;260(2):521-30.

A Spectrum of Abnormality in Pediatric Neck: Practical Imaging Choices and Interpretation
Caroline D. Robson, MBChB

Regarding retropharyngeal abscess (RPA):

A. Contrast-enhanced CT (CECT) is highly sensitive for the detection of RPA
B. CECT is highly specific for the detection of RPA
C. Even small abscesses require surgical drainage
D. A narrowed internal carotid artery (ICA) next to RPA is a poor prognostic sign
E. Rotary subluxation is a common complication of RPA

Answer: A

CECT is sensitive but not very specific for diagnosis of RPA. Small abscesses < 2 cc are sometimes managed conservatively initially. Failure to respond to IV antibiotics and/or deterioration on follow up CT indicates a need for surgical drainage. A narrowed ICA is frequently seen and is not a poor prognostic sign. Prevertebral muscular spasm that produces torticollis frequently accompanies RPA but rotary subluxation per se is an infrequent complication

Reference:
Stone, M. E., D. L. Walner, Koch B. L. et al. (1999). "Correlation between computed tomography and surgical findings in retropharyngeal inflammatory processes in children." Int J Pediatr Otorhinolaryngol **49**(2): 121-5.

Embryology and Diagnostic Approach in Spinal Dysraphism
L. Santiago Medina, MD, MPH and Esperanza Pacheco-Jacome, MD

Which of the following is associated with premature disjunction of the Cutaneus Ectoderm from the Neuroectoderm?

A. Myelomeningocele/myelocele
B. Dermal sinus
C. Lipomyelomeningocele/lipomyelocele
D. Diastematomyelia
E. Myelocystocele

ANSWER: C

During Neurulation, there is disjunction of the cutaneus ectoderm from the neuroectoderm, and fusion in the midline of the cutaneous ectoderm. A premature disjunction of the ectoderms, will allow the connective tissue that surrounds the neural tube, to enter in the neural sulcus to later differentiate into fat.

Which of the following structures are formed from the "Caudal Cell Mass"?

A. Filum Terminale
B. Conus medullaris
C. Urorectal septum
D. Sacral vertebrae
E. All of the above

ANSWER: E

The Caudal Cell Mass is a conglomerate of totipotential cells, responsible for the formation of the vertebrae distal to mid S1, distal spinal cord (conus medullaris, filum terminalis, ventriculus terminalis), and the urogenital system and primitive colon, by a process called canalization and retrogressive differentiation.

1. Medina LS. Spinal dysraphism: categorizing risk to optimize imaging. Pediatr Radiol. 2009; 39 Suppl 2: S242 – 246.
2. Venkataramana NK. Spinal dysraphism. J Pediatr Neurosci. 2011; 6 (Suppl 1): S31 – S40.

Which of the following exams has the highest combined sensitivity and specificity?

A. Plain films
B. Ultrasound
C. MRI
D. CT
E. Physical Exam

Answer: C

In low risk patients with a low lumbar or intergluteal dimple which is the preferred initial imaging study?

A. CT
B. MRI
C. Plain Films
D. Ultrasound
E. None of the above.

Answer: D

References:

1. Medina LS, Crone K, Kuntz KM. Newborns with suspected occult spinal dysraphism: a cost-effectiveness analysis of diagnostic strategies. Pediatrics. 2001 Dec;108(6):E101.
2. Brophy JD, Sutton LN, Zimmerman RA, Bury E, Schut L. Magnetic resonance imaging of lipomyelomeningocele and tethered cord. Neurosurgery. 1989 Sep;25(3):336-40.

3. Moufarrij NA, Palmer JM, Hahn JF, Weinstein MA. Correlation between magnetic resonance imaging and surgical findings in the tethered spinal cord. Neurosurgery. 1989 Sep;25(3):341-6.

Infectious Diseases of the World: From Review to Updates in Imaging

Viral Infections in Children: Beyond SARS and H1N1

Winnie C.W. Chu, MD, FRCR (AOSPR)

Severe Acute Respiratory Syndrome (SARS) in 2003 and Swine-origin influenza A (H1N1) pandemic in 2009 are the two major outbreaks of viral infection in the last decade. Which one of the following is NOT the known similarity among the two conditions:

A. Initial chest radiographs may not show abnormalities.
B. Chest radiographs rather than high resolution CT are usually adequate for follow up.
C. The most prominent radiographic and CT features are ground glass opacification and consolidation, commonly subpleural in location
D. Pleural effusion, adenopathy, cavities and centrilobular nodules are not common radiological features
E. Children of young age have relatively mild disease when compared with adults.

Answer: E

REFERENCES:

1. Stockman LJ, Massoudi MS, Helfand R, Erdman D, Siwek AM, Anderson LJ, et al. Severe acute respiratory syndrome in children. The Pediatric infectious disease journal. 2007;26(1):68-74. Epub 2007/01/02.
2. Babyn PS, Chu WC, Tsou IY, Wansaicheong GK, Allen U, Bitnun A, et al. Severe acute respiratory syndrome (SARS): chest radiographic features in children. Pediatr Radiol. 2004;34(1):47-58.
3. Hon KL, Leung CW, Cheng WT, Chan PK, Chu WC, Kwan YW, et al. Clinical presentations and outcome of severe acute respiratory syndrome in children. Lancet. 2003;361(9370):1701-3.
   Wong KT, Antonio GE, Hui DS, Lee N, Yuen EH, Wu A, et al. Severe acute respiratory syndrome: radiographic appearances and pattern of progression in 138 patients. Radiology. 2003;228(2):401-6. Epub 2003/05/22.
4. Wong KT, Antonio GE, Hui DS, Lee N, Yuen EH, Wu A, et al. Thin-section CT of severe acute respiratory syndrome: evaluation of 73 patients exposed to or with the disease. Radiology. 2003;228(2):395-400. Epub 2003/05/10.
5. Halasa NB. Update on the 2009 pandemic influenza A H1N1 in children. Current opinion in pediatrics. 2010;22(1):83-7. Epub 2010/01/14.
6. Aviram G, Bar-Shai A, Sosna J, Rogowski O, Rosen G, Weinstein I, et al. H1N1 influenza: initial chest radiographic findings in helping predict patient outcome. Radiology. 2010;255(1):252-9. Epub 2010/03/24.

7. Marchiori E, Zanetti G, D'Ippolito G, Verrastro CG, Meirelles Gde S, Capobianco J, et al. Swine-origin influenza A (H1N1) viral infection: thoracic findings on CT. AJR American journal of roentgenology. 2011;196(6):W723-8. Epub 2011/05/25.

RATIONALE:
In a review of 135 pediatric patients confirmed with SARS from Hong Kong, Taiwan, Canada and Singapore, patients of 12 years of age or younger had milder disease. They were less likely to receive supplemental oxygen ,methylprednisolone, or to be admitted to the intensive care unit. During the H1N1 pandemic 2009, though majority of cases in children have been mild, death and severe illnesses have mostly occurred in children below 5 years of age (19% of H1N1 pediatric death in United State), while 67% of H1N1 pediatric death is related one or more high-risk medical conditions.

Option A is not correct.
The initial chest radiographs were reported to be normal in 35% and 20% of pediatric and adult patients suffering from SARS respectively. In general, 60% of patients with H1N1 infection were found to be normal at presentation.
Option B is not correct.
During both SARS and H1N1 outbreaks, chest radiographs were considered to be adequate for follow up. The radiographic pattern has been shown to be useful for predicting clinical outcome. CT (high resolution and low dose technique in particular for pediatric population) was performed for suspected cases with subtle radiographic findings at presentation. In general, CT is reserved for investigation of suspected complications associated with the lower respiratory infection during follow up.
Option C is not correct.
For SARS, ground glass opacification (~70%), consolidation (~15%) and mixed pattern (~15%) are the dominant radiological features, commonly with peripheral subpleural location (~70%). For H1N1, the predominant radiological features are ground glass opacification (~70%) and consolidation (~60%), frequently bilateral and multifocal (60-70%) and commonly in subpleural and peribronchovascular distribution.
Option D is not correct.
In both SARS and H1N1 patients who had radiological abnormalities, pleural effusion, adenopathy, cavities and centrilobular nodules were absent in majority of cases.

Pediatric TB Infection: Current Status and Updates
Bernard F. Laya, DO (AOSPR)

Which of the following is correct regarding medical imaging of childhood tuberculosis?

A. Radiographs are highly sensitive and specific for diagnosis of intrathoracic TB in children.
B. In children with primary TB and nodal involvement, erosion of the nodes into the adjacent airway is a frequent cause of airway involvement.
C. The most common form of musculoskeletal TB involvement is TB osteomyelitis.
D. Dense basal cistern sign, a highly specific sign of TB meningitis is best noted following intravenous administration of iodinated contrast.

E. The most common area of gastrointestinal involvement of TB is the descending colon.

Answer: B

References:

1. De Villiers RV, Andronikou S, Van de Westhuizen S. Specificity of chest radiographs in the diagnosis of paediatric pulmonary TB and the value of additional high-kilovolt radiographs. Australas Radiol. 2004 Jun; 48(2): 148-53
2. Kashyap S, Mohapatra PR, Saini V. Endobronchial Tuberculosis. Indian J chest Dis Allied Sci. 2003; 45:247-256
3. Harisinghani, M.G., Mcloud, T.C., Shepard, J.O., et al. Tuberculosis From Head to Toe. Radiographics. 2000 Mar-Apr;20(2):449-70; quiz 528-9, 532
4. Andronikou S, Wieselthaler N, Smith B, Douis H, et al. Value of early follow-up CT in paediatric tuberculous meningitis. Ped Rad 2005 Nov;35(11):1092-9. Epub 2005 Aug 4
5. Balthazar E, Gordon R, Hulnick D. Ileocecal tuberculosis: CT and radiologic evaluation. American Journal of Roentgenology. 1990 Mar 154: 499-503

Rationale:

1. A is incorrect. Chest x-rays are moderately sensitive but nonspecific for diagnosis of pulmonary TB in children.
2. C is incorrect. The most common form of musculoskeletal TB involvement is TB spondylitis.
3. D is incorrect. Dense basal cistern sign is noted in non-contrast CT scan of the brain.
4. E is incorrect. The most common area of gastrointestinal involvement with TB is the terminal ileum.

The World of Parasites: Overview of Imaging Findings

Pedro A. Daltro, MD (SLARP)

The patient is a 2-year-old who initially presented with bilious vomiting. Initial chest and abdominal radiographs showed bowel loops with air-fluid levels and presence of rectal air. Based on these ultrasound images, what is the most likely diagnosis?

1. Intussusception
2. Lymphoma
3. Ascariasis
4. Midgut volvulus
5. Sarcoma

Answer: C

References:

1. Ortega CD, Ogawa NY, Rocha MS et al. Helmintic diseases in the Abdomen: An Epidemiologic and Radiological Overview. Radiographics 2010; 30:253-267.
2. Das CJ, Kumar J, Debnath J, Chandhry A. Imaging of Ascariasis. Australas Radiol 2007;51:500-506.

3. Park MS, Kim KW, Há HK, Lee DH. Intestinal Parasitic Infection. Abdom Imaging 2008; 33:166-171

Infectious Diseases of Africa: Facing the Challenge
Omolola M. Atalabi, MD (ASR)

The major infectious diseases contributing to the high child mortality rate in sub-Sahara Africa include the following except:

A. Pneumonia
B. Malaria
C. Polio
D. Diarrhoea
E. Tuberculosis

Answer: C

References:

1. Black R E, Cousens S, Johnson H L, Lawn JE, Rudan I, Bassani RD et al, Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010; 375: 1969–87
2. You D, Jones G, Wardlaw T. Level and Trends in Child Mortality1990-2010, Report 2011; 1-24
3. Guerin PJ, Olliaro P, Nosten F, Druilhe P, Laxminarayan R, Binka F et al. Malaria: current status of control, diagnosis, treatment, and a proposed agenda for research and development. Lancet Infect Dis 2002; 2: 564–73
4. Bennington, Linda. "Polio." Gale Encyclopedia of Medicine, 3rd ed.. 2006. *Encyclopedia.com.* (Accessed December 15, 2011). http://www.encyclopedia.com/doc/1G2-3451601283.html

Rationale:
All the other options (a b, d and e) and HIV/ AIDS are the 5 major infectious diseases responsible for the very high increase in infant mortality rate in the sub Sahara Africa. Although Polio is an infectious disease but its contribution to child mortality rate has declined tremendously since the Global Polio Eradication Initiative was lunched and this has led to the wider coverage of polio vaccination, increased awareness through health education and participation by funding the initiative by different Governments in the sub region.