SPR 2015 POSTGRADUATE COURSE

Oncologic Imaging 1

Provided for further study

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With regard to the FDG uptake in the upper chest shown in the image:

A. Uptake of FDG by this tissue occurs in different locations in pediatric patients than in adult patients
B. Uptake of FDG by this tissue is more common in pediatric patients
C. Uptake of FDG by this tissue can be prevented by warming the FDG dose
D. Uptake of FDG by this tissue cannot be distinguished from pathologic uptake based on imaging alone
E. This tissue has no known physiologic function

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The FDG uptake indicated in the figure is uptake in brown (metabolically active) fat.

- Option A is **NOT** correct – the distribution of brown fat in children and young adults is very similar to the distribution in adult patients
- Option B is **CORRECT** – the incidence of brown fat uptake is higher in young patients, up to 47%
- Option C is **NOT** correct – the patient can be warmed, not the dose
- Option D is **NOT** correct – brown fat uptake localizes to areas of fat on CT and can generally be distinguished from pathologic uptake
- Optoin E is **NOT** correct – brown fat functions in thermoregulation

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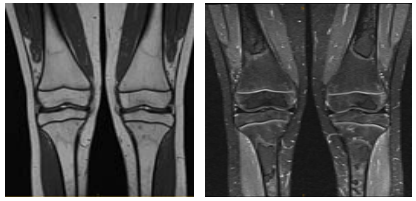
With regard to the FDG uptake in the upper chest shown in the image:

- Gelfand MJ, et al. Pre-medication to block [(18)F]FDG uptake in the brown adipose tissue of pediatric and adolescent patients. Pediatr Radiol. 2005; 35(10): 984-90

- Hao R, et al. Brown adipose tissue: distribution and influencing factors on FDG PET/CT scan. J Pediatr Endocrinol Metab. 2012; 25(3-4): 233-7

Visualize the Future

9 y/o girl underwent screening MR on day 40 during induction therapy for non-Hodgkin's lymphoma. Which of the following is true about the findings?



A. Characteristic of lymphoma
B. Should resolve with continued therapy
C. Have been demonstrated only in adolescents who have reached skeletal maturity
D. They herald rapid evolution to extensive osteonecrosis
E. Bilaterality is atypical

9 year old girl underwent MR on day 40 during induction therapy for non-Hodgkin's lymphoma.

- Option D is **CORRECT**. These findings typically herald rapid evolution of extensive osteonecrosis as shown in the follow-up images below.
- In contrast to the commonly described MR changes of osteonecrosis (well-defined, geographic lesions that characteristically are of decreased signal on T1- and increased signal on T2-weighted or STIR sequences), these earlier changes are less conspicuous, often poorly defined, and often demarcated by subtle edema.

9 year old girl underwent MR on day 40 during induction therapy for non-Hodgkin's lymphoma.

- Krishnan A, et al. Primary bone lymphoma: radiographic-MR imaging correlation. Radiographics. 2003;23(6):1371-83
- Sansgiri RK, et al. Unique MRI findings as an early predictor of osteonecrosis in pediatric acute lymphoblastic leukemia. AJR Am J Roentgenol. 2012;198(5):W432-9
- Karimova EJ, et al. How does osteonecrosis about the knee progress in young patients with leukemia?: a 2- to 7-year study.Clin Orthop Relat Res. 2010;468(9):2454-9
- Kadan-Lottick NS, et al. Osteonecrosis in adult survivors of childhood cancer: a report from the childhood cancer survivor study. J Clin Oncol. 2008 Jun 20;26(18):3038-45
- Karimova EJ, et al. MRI of knee osteonecrosis in children with leukemia and lymphoma: Part 2, clinical and imaging patterns.AJR Am J Roentgenol. 2006;186(2):477-82
- Karimova EJ, et al. MRI of knee osteonecrosis in children with leukemia and lymphoma: Part 1, observer agreement AJR Am J Roentgenol. 2006; 186(2):470-6

What is the source of attenuation correction for PET-CT scanners?

A. None
B. X-rays
C. Germanium-68
D. Cesium-137

What is the source of attenuation correction for PET-CT scanners?

- Option A is **NOT** correct. Attenuation correction is required due to loss of photon counts between 50-95%
- Option B is **CORRECT**. X-rays from the CT scanner are used for attenuation correction.
- Options C and D are **NOT** correct. These long lived radioactive sources were used to create transmission scans for attenuation correction in PET-only cameras

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What is the source of attenuation correction for PET-CT scanners?

- Essentials of Nuclear Medicine Imaging, 5th edition, Chapter 13, Mettler and Guiberteau

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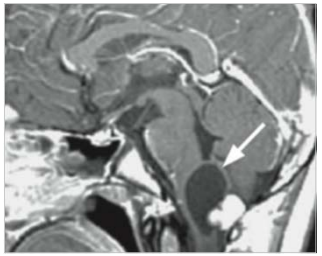
This patient has a known cancer predisposition syndrome with characteristic tumor shown at the arrow. Which of the following tumors are NOT commonly associated with this syndrome?



A. Clear cell carcinoma of the kidney
B. Pheochromocytoma
C. Endolymphatic sac tumor
D. Choroid plexus carcinoma
E. Hemangioblastoma

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Which of the following tumors are not commonly associated with this syndrome?

- Option D is **CORRECT**. This is an older teenager with a hemangioblastoma, a characteristic tumor seen in von Hippel Lindau disease.
- VHL is commonly associated with all of the answer choices except choriod plexus carcinoma, a tumor which is more characteristically seen in Li-Fraumeni syndrome

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Which of the following tumors are not commonly associated with this syndrome?

- Choyke PL, et al. von Hippel-Lindau disease: genetic, clinical, and imaging features. Radiology 1995; 194: 629-642
- Lonser RR, et al. Von Hippel-Lindau disease. Lancet 2003; 361: 2059-2067
- Gozali AE, et al. Choroid plexus tumors; management, outcome, and association with the Li–Fraumeni syndrome: The Children's Hospital Los Angeles (CHLA) experience, 1991–2010. Pediatric Blood & Cancer 2012; 58: 905–909
- Monsalve J, et al. Imaging of Cancer Predisposition Syndromes in Children. Radiographics 2011;31:263-280

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In children with neurofibromatosis, FDG PET/CT scan may be helpful to direct biopsy of a specific lesion if the SUVmax is:

A. Above mediastinum but less than liver
B. Above mediastinum and above liver
C. Less than 3.5 on initial and delayed imaging
D. Greater than 3.5 on initial and delayed imaging

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In children with neurofibromatosis, FDG PET/CT scan may be helpful to direct biopsy of a specific lesion if the SUVmax is:

- Option D is **CORRECT**.
- Options A and B are **NOT** correct. They apply to Deauville criteria for patients with lymphoma and are not applicable to lesions of neurofibromatosis.
- Option D is **NOT** correct. Lesions with SUVmax of greater than 3.5 may have more malignant potential and hence might be biopsied

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In children with neurofibromatosis, FDG PET/CT scan may be helpful to direct biopsy of a specific lesion:

- Tian R, et al. Dual-time point PET/CT with F-18 FDG for the differentiation of malignant and benign bone lesions. Skeletal Radiol 2009;38(5):451-8.

Visualize the Future

Which of the following tissues normally show restricted diffusion on DW-MRI?

A. Brain, spinal cord, nerve plexuses
B. Normal lymph nodes
C. Normal red marrow
D. Normal liver
E. A-C

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Which of the following tissues normally show restricted diffusion on DW-MRI?

- Option E is **CORRECT**. Brain, spinal cord, nerve plexuses, normal lymph nodes and red marrow all normally show restricted diffusion.
- Option D is **NOT** correct. Normal liver should not restrict diffusion.

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Which of the following tissues normally show restricted diffusion on DW-MRI?

- Gawande RS, et al. Role of diffusion-weighted imaging in differentiating benign and malignant pediatric abdominal tumors. Pediatr Radiol 2013; 43: 836-845

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Which patient is least likely to have widespread anomalies that would benefit from whole body MRI?

A. Infant with 7 cutaneous infantile hemangiomas
B. Neonate with bizarre subcutaneous fatty masses, left leg overgrowth with distended veins and nevi
C. Previously healthy adolescent with an abdominal aortic aneurysm
D. Pre-adolescent with numerous phlebolith-containing soft tissue masses and bubbly lucent bone lesions that show endosteal scalloping
E. Preschooler with new pleural effusions, cystic abdominal mass, expansile lucent bone lesions, and numerous spleen lesions

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Which patient is least likely to have widespread anomalies that would benefit from whole body MRI?

- Option A is **CORRECT**. Patients with 5 or more cutaneous infantile hemangiomas are at risk for visceral hemangiomas.
- The liver is the most commonly involved organ in this setting, and can be associated with heart failure, hepatic failure, abdominal compartment syndrome, and hypothyroidism. Abdominal ultrasound is usually a sufficient. Liver MRI is rarely necessary if the sonographic imaging or clinical course is atypical.
- Whole body MRI, however, does not have a role in this particular scenario.

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Which patient is least likely to have widespread anomalies that would benefit from whole body MRI?

- Christison-Lagay ER, et al. Hepatic hemangiomas: subtype classification and development of a clinical practice algorithm and registry. J Pediatr Surg. 2007;42(1):62-7
- Uller W, et al. Overgrowth syndromes with complex vascular anomalies. Semin Pediatr Surg. 2014 Aug;23(4):208-15.
- Callicutt CS, et al. Idiopathic renal artery and infrarenal aortic aneurysms in a 6-year-old child: case report and literature review. J Vasc Surg. 2005;41(5):893-6.
- Korchi AM, et al. Whole-body magnetic resonance imaging: an essential tool for diagnosis and work up of non-oncological systemic diseases in children. Minerva Pediatr. 2014;66(3):169-76.
- Adams DM, Hammill A. Other vascular tumors. Semin Pediatr Surg. 2014;23(4):173-7.
- Lala S, et al. Gorham-Stout disease and generalized lymphatic anomaly--clinical, radiologic, and histologic differentiation. Skeletal Radiol. 2013;42(7):917-24.
- Farmakis SG, Khanna G. Extracardiac applications of MR blood pool contrast agent in children. Pediatr Radiol. 2014;44(12):1598-609.
- Knuttinen MG, et al. Blood Pool Contrast-enhanced Magnetic Resonance Angiography with Correlation to Digital Subtraction Angiography: A Pictorial Review. J Clin Imaging Sci. 2014 29;4:63.

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12-year-old with after treatment of stage II Hodgkin disease. Which one of the following is the MOST LIKELY etiology of the abnormalities?

A. Infection
B. Metastasis
C. Granulocyte colony stimulating factor (GCSF) therapy
D. Osteonecrosis

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12-year-old with after treatment of stage II Hodgkin disease. Which one of the following is the MOST likely etiology of the abnormalities?

- Option D is **CORRECT** – osteonecrosis.
- Hodgkin and Non-Hodgkin disease patients are at greater risk to develop osteonecrosis. Although radiographs may reveal serpinious sclerosis or articular collapse, MRI can detect bone ischemia and necrosis at a much earlier stage.
- The classic MR findings include serpiginous, well defined low T1 and high T2 lines within the medullary cavity.
- Whole-body MRI may detect greater burden of osteonecrosis than clinically suspected.

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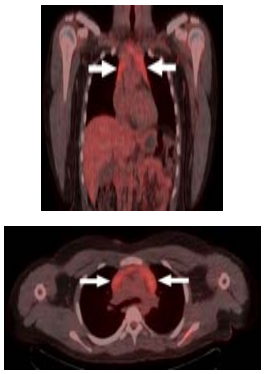
12-year-old with after treatment of stage II Hodgkin disease. Which one of the following is the MOST likely etiology of the abnormalities?

- Kellenberger CJ, Epelman M, Miller SF, Babyn PS: Fast STIR whole-body MR imaging in children. Radiographics 2004, 24(5):1317-1330.

With regard to the FDG uptake indicated in the images:

A. Highly likely to be a malignant
B. Physiologic uptake of FDG in this location is more common in adult patients
C. When physiologic uptake occurs in this location, heterogenous FDG-uptake is expected
D. Uptake can be suppressed by warming the patient
E. Eliminating a physiologic stress may cause an increase in soft tissue and homogenous FDG uptake at this location



The FDG uptake indicated in the figure is uptake in normal thymus.

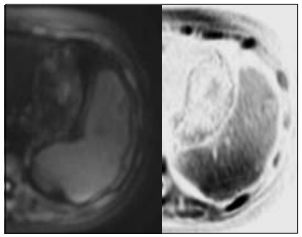
- Option A is **NOT** correct – this is normal thymic uptake of FDG
- Option B is **NOT** correct – thymic uptake is more commonly observed in pediatric and young adult patients.
- Option C is **NOT** correct – normal thymic uptake is homogenous. Heterogeneity should raise suspicion for involvement by disease
- Option D is **NOT** correct – warming has not been shown to influence thymic uptake of FDG. Warming is important to limit brown fat uptake
- Optoin E is **correct** – thymic rebound, following elimination of a physiologic or disease stress, appears as an enlarged, more FDG-avid thymus

With regard to the FDG uptake indicated in the images:

- Brink I, et al. Increased metabolic activity in the thymus gland studied with 18F-FDG PET: age dependency and frequency after chemotherapy. J Nucl Med. 2001; 42(4): 591-5

How can false positive DWI signal of normal spleen, marrow and lymph nodes be suppressed?

A. Inject gadolinium chelate
B. Oral water before scan
C. Inject iron oxide nanoparticles
D. Apply fat saturation
E. All of the above



How can false positive DWI signal of normal spleen, marrow and lymph nodes be suppressed?

- Option A is **NOT** correct. IV gadolinium does not have a significant effect on DWI signal.
- Option B is **NOT** correct. Oral water would not suppress DWI signal.
- Option C is **CORRECT**. Injection of iron oxide particles leads to signal loss in the normal reticulo-endothelial system.
- Option D is **NOT** correct. DWI images are already fat saturated.

How can false positive DWI signal of normal spleen, marrow and lymph nodes be suppressed?

- Klenk C, et al. Ionising radiation-free whole-body MRI versus 18F-fluorodeoxyglucose PET/CT scans for children and young adults with cancer: a prospective, non-randomised, single-centre study. Lancet-Oncology 2014; 15: 275-285

What is a likely benefit of PET/MR over PET/CT scanners?

A. Superior PET resolution
B. Faster image acquisition
C. Improved anatomic resolution of cortical bone
D. Decreased patient radiation exposure

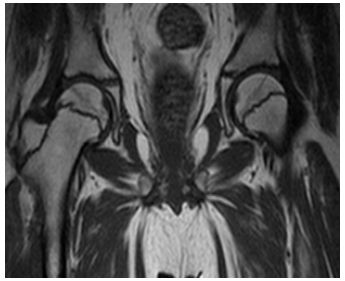
What is a likely benefit of PET/MR over PET/CT scanners?

- Option A is **NOT** correct. Available PET/MR scanners have equal or lower resolution than their corresponding PET/CT counterparts.
- Option B is **NOT** correct. Even simple performance of MRAC takes longer than CTAC.
- Option C is **NOT** correct. CT is superior to MR for imaging of cortical bone. It is hoped that superior MR imaging of bone marrow relative to CT will prove clinically useful in PET/MR.
- Option D is **CORRECT**. CT can contribute 45% or more of the total effective dose of PET/CT.

What is a likely benefit of PET/MR over PET/CT scanners?

- Shafer JF, et al. Simultaneous Whole-Body PET/MR Imaging in Comparison to PET/CT in Pediatric Oncology: Initial Results. Radiology 2014; 273: 220-231
- Torigian DA, et al. PET/MR Imaging: Technical Aspects and Potential Clinical Applications. Radiology 2013; 267: 26-44
- Jadvar H, Colletti PM. Competitive advantage of PET/MRI. Eur J Radiol 2014; 83: 84-94

11 y/o girl diagnosed with acute lymphoblastic lymphoma. Coronal T1-weighted MR obtained 7 months after the initiation of chemotherapy.



A. The extent of this patient's femoral head lesions are expected to progress to collapse.
B. With skeletal maturation, osteonecrosis becomes less prevalent.
C. Teenage patients are at less risk for osteonecrosis than pre-teens.
D. No genetic predisposition for osteonecrosis has been reported.
E. Bilateral involvement is uncommon in the development of osteonecrosis in children treated for malignancies.

11 year old girl 7 months after the initiation of chemotherapy.

- Option A is **CORRECT**. The lesions in this patient involve nearly the entire articular surface of both femoral heads. Lesions involving > 30% of the articular surface in these patients are at great risk of progressing to collapse.
- Options B and C are **NOT** correct. Teenagers have repeatedly been shown to be at greater risk for developing glucocorticoid-induced osteonecrosis than preteens.
- Option D is **NOT** correct. Several polymorphisms have been associated with the development of osteonecrosis and include: PAI-1 (SERPINE1), ACP1
- Option E is **NOT** correct. Due to the systemic exposure of chemotherapy treatment, all joints are at risk for developing osteonecrosis. Bilateral involvement of joints is typical.

11 year old girl 7 months after the initiation of chemotherapy.

- Kadan-Lottick NS, et al. Osteonecrosis in adult survivors of childhood cancer: a report from the childhood cancer survivor study. J Clin Oncol. 2008; 26(18):3038-45
- Karimova EJ, et al. Femoral head osteonecrosis in pediatric and young adult patients with leukemia or lymphoma. J Clin Oncol. 2007 ;25(12):1525-31.
- Mont MA, et al. The natural history of untreated asymptomatic osteonecrosis of the femoral head: a systematic literature review.
- J Bone Joint Surg Am. 2010 ; 92(12): 2165-70
- Kerachian MA, et al. Glucocorticoids in osteonecrosis of the femoral head: A new understanding of the mechanisms of action The Journal of Steroid Biochemistry and Molecular Biology, Volume 114, Issues 3–5, 2009, 121–128
- Janke LJ, et al. Primary epiphyseal arteriopathy in a mouse model of steroid-induced osteonecrosis. Am J Pathol. 2013;183(1):19-25
- French D, et al. Children's Oncology Group. Blood. 2008; 111(9):4496-9
- Kawedia JD, et al. Pharmacokinetic, pharmacodynamic, and pharmacogenetic determinants of osteonecrosis in children with acute lymphoblastic leukemia. Blood. 2011 Feb 24;117(8):2340-7

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In a child with NF1, the sensitivity for detection of MPNST is BEST described as:

A. **FDG PET/CT greater than MRI**
B. DOPA PET/CT greater than MRI
C. MRI greater than DOPA PET/CT
D. MRI greater than FDG PET/CT

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In a child with NF1, the sensitivity for detection of MPNST is BEST described as:

- The **CORRECT** answer is option A.
- Both FDG PET/CT and MRI will detect benign and malignant tumors in patients with NF1, but FDG PET/CT has been identified as having greater sensitivity.
  - MRI has been reported to detect 66% lesions but PET/CT has detected greater than 90% lesions.
- Options B, C and D are **NOT** correct. FDOPA is not used for detection of tumors in NF1 but can be used for neuroendocrine tumors

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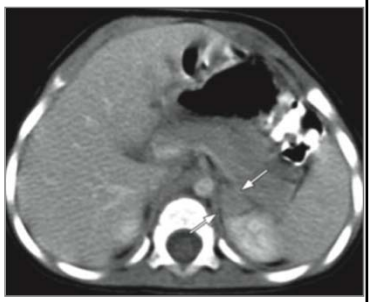
In a child with NF1, the sensitivity for detection of MPNST is BEST described as:

- Ambrosini V, et al. Current status of PET imaging of neuroendocrine tumors ([18F]FDOPA, [68Ga]tracers, [11C]/[18F]-HTP). Q J Nucl Med Mol Imaging 2015; 12: [Epub ahead of print]
- Derlin T, et al. Comparative effectiveness of 18F-FDG PET/CT versus whole-body MRI for detection of malignant peripheral nerve sheath tumors in neurofibromatosis type 1. Clin Nucl Med 2013; 38(1): e19-25.

Visualize the Future

13 month-old girl with confirmed choroid plexus carcinoma and Li-Fraumeni syndrome. Which one of the following is the MOST LIKELY etiology of the abnormality marked by the arrow?



A. Ectopic pancreas
B. Neuroblastoma
C. Adrenal adenoma
D. Adrenocortical carcinoma
E. Wilms tumor

13 month-old girl with confirmed choroid plexus carcinoma and Li-Fraumeni syndrome. Which one of the following is the MOST likely etiology of the abnormality?

- Option D is **CORRECT**. In this child with Li-Fraumeni syndrome masses of the adrenal gland are most likely to be adrenocortical carcinoma.
- The other answers are not associated with Li-Fraumeni syndrome.

13 month-old girl with confirmed choroid plexus carcinoma and Li-Fraumeni syndrome. Which one of the following is the MOST likely etiology of the abnormality?

- Malkin D. Li-Fraumeni syndrome. In: GD Hammer, T Else (eds) Adrenocortical carcinoma 2011. Springer, 2011;173-191
- Monsalve J, Kapur J, Malkin D, Babyn P. Imaging of Cancer Predisposition Syndromes in Children. *Radiographics*. 2011;31:263-280

Which patient is most likely to benefit from use of a blood pool MR contrast agent?

A. Infant with 7 cutaneous infantile hemangiomas
B. Neonate with bizarre subcutaneous fatty masses, left leg overgrowth with distended veins and nevi
C. Previously healthy adolescent with an abdominal aortic aneurysm
D. Pre-adolescent with numerous phlebolith-containing soft tissue masses and bubbly lucent bone lesions that show endosteal scalloping
E. Preschooler with new pleural effusions, cystic abdominal mass, expansile lucent bone lesions, and numerous spleen lesions

Which patient is most likely to benefit from use of a blood pool MR contrast agent?

- Option C is **CORRECT**. A previously healthy patient with newly discovered abdominal aortic aneurysm should undergo generalized screening for other aneurysms.
- Patient in option A will likely not have any vessel anomalies, while patients in options B, D and E will have slow flow vascular malformations, predominantly in mass form.

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Which patient is most likely to benefit from use of a blood pool MR contrast agent?

- Christison-Lagay ER, et al. Hepatic hemangiomas: subtype classification and development of a clinical practice algorithm and registry. J Pediatr Surg. 2007;42(1):62-7
- Uller W, et al. Overgrowth syndromes with complex vascular anomalies. Semin Pediatr Surg. 2014 Aug;23(4):208-15.
- Callicutt CS, et al. Idiopathic renal artery and infrarenal aortic aneurysms in a 6-year-old child: case report and literature review. J Vasc Surg. 2005;41(5):893-6.
- Korchi AM, et al. Whole-body magnetic resonance imaging: an essential tool for diagnosis and work up of non-oncological systemic diseases in children. Minerva Pediatr. 2014;66(3):169-76.
- Adams DM, Hammill A. Other vascular tumors. Semin Pediatr Surg. 2014;23(4):173-7.
- Lala S, et al. Gorham-Stout disease and generalized lymphatic anomaly--clinical, radiologic, and histologic differentiation. Skeletal Radiol. 2013;42(7):917-24.
- Farmakis SG, Khanna G. Extracardiac applications of MR blood pool contrast agent in children. Pediatr Radiol. 2014;44(12):1598-609.
- Knuttinen MG, et al. Blood Pool Contrast-enhanced Magnetic Resonance Angiography with Correlation to Digital Subtraction Angiography: A Pictorial Review. J Clin Imaging Sci. 2014 29;4:63.

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Regarding the administration of intravenous (IV) gadolinium for whole Body MR imaging, which one of the following statements is correct?

A. Should be administered immediately after the localizing sequences.
B. Should be administered only if diffusion weighted images are obtained.
C. Usually administered to enhance visualization of pathologic lesions.
D. Usually not required for whole body MR imaging. If administered, the STIR sequence should be performed after the administration of IV gadolinium.
E. Usually not required for whole body MR imaging. If administered, the STIR sequence should be performed before the administration of IV gadolinium.

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Regarding the administration of intravenous (IV) gadolinium for whole Body MR imaging, which one of the following statements is correct?

- Option E is **CORRECT**. The vast majority of pathologic lesions are proton rich and have high signal intensity lesions on STIR images, so IV gadolinium containing contrast is not usually needed.
- Option D is **NOT** correct. If IV contrast is used, the longitudinal magnetization of fat or other tissues with short T1 relaxation times is nulled on STIR images, resulting in a so-called negative enhancement, which may obscure the visualization of pathologic lesions.

Visualize the Future

Regarding the administration of intravenous (IV) gadolinium for whole Body MR imaging, which one of the following statements is correct?

- Kellenberger CJ, Epelman M, Miller SF, Babyn PS. Fast STIR whole-body MR imaging in children. Radiographics. 2004;24:1317-30
- Krinsky G, Rofsky NM, Weinreb JC. Nonspecificity of short inversion time inversion recovery (STIR) as a technique of fat suppression: pitfalls in image interpretation. AJR Am J Roentgenol 1996; 166: 523-526