What is the best description of the MRI technique shown?

A. Diffusion-weighted imaging
B. **Chemical shift imaging**
C. Hepatocyte specific contrast agent imaging
D. Susceptibility-weighted imaging

• Option A is NOT correct. The MR images displayed are not diffusion-weighted.
• Option B is **CORRECT**. The MR images shown above are T1-weighted gradient recalled echo images that are in-phase (A) and out-of-phase (B), respectively. The lesion within the anterior liver loses signal on the out-of-phase image, suggesting the presence of lipid. Lipid-containing liver lesions are usually hepatocellular neoplasms, either adenomas or carcinomas.
• Option C is NOT correct. The images above show no evidence on hepatocyte specific contrast agent imaging. There is no liver parenchymal enhancement, and no excreted contrast material is present in the biliary system.
• Option D is NOT correct. There are no clinical applications for susceptibility-weighted imaging of the pediatric abdomen at this time. This MR technique is most commonly used to evaluate the...
What contrast agent was used for the MRI exam in this teenage girl with hepatocellular adenoma?

A. Dotarem (gadoterate meglumine)
B. Eovist (gadoxetate disodium)
C. Ablavar (gadofosveset trisodium)
D. Prohance (gadoteridol)
E. Gadavist (gadobutrol)

• Options A, C, D, and E are NOT correct. None of these contrast agents demonstrate hepatocyte uptake or biliary excretion. These contrast agents are exclusively excreted by the kidneys.
• Option B is CORRECT. The images provided show excreted contrast material in the biliary system typical of hepatocyte specific contrast agent excretion. A hypointense lesion in the right hepatic lobe is consistent with the biopsy result of hepatocellular adenoma.

What contrast agent was used for the MRI exam in this 10-month-old with palpable abdominal mass?

A. Lymphoma
B. Nephrogenic rests
C. Bilateral Wilms tumor
D. Diffuse hyperplastic perilobar nephroblastomatosis (DHPLN)
Which of the following is the CORRECT diagnosis in this 10-month-old with palpable abdominal mass?

- Option A is NOT correct. Though lymphoma can present with bilateral renal masses, these patients are typically older, have evidence of lymphadenopathy, and multiple renal masses. The young age of this patient, lack of retroperitoneal lymphadenopathy, and mid-rib thickening of the renal cortex argues against the diagnosis of lymphoma.

- Option B is NOT correct. Nephrogenic rests are a clue of persistent embryonic metanephric tissue that persist beyond 10 weeks gestation. Nephrogenic rests can be single or multiple. These are precursor lesions for Wilms tumor and imaging differentiation between nephrogenic rests and Wilms tumor is challenging.

- Option C is NOT correct. Bilateral Wilms tumor is not correct. Even though the kidney is enlarged, the mid-rib like expansion of the cortex with uniform attenuation supports the diagnosis of DHPLN rather than Wilms tumor. This imaging differentiation is important to avoid unnecessary surgical intervention (surgery or biopsy).

- Option D is CORRECT. DHPLN is characterized by massive enlargement of one or both kidneys with a mid-rib like expansion of the renal cortex by nephroblastoma tissue and preservation of renal shape. These patients are at high risk of developing Wilms tumor and require more aggressive clinical management than children with multifocal nodular nephrogenic rests.

Which of the following is the CORRECT diagnosis in this 10-month-old with palpable abdominal mass?


In the image shown below, which of the following imaging findings warrants chemotherapy prior to nephrectomy?

- Option A is NOT correct. Though presence of ascites beyond cul-de-sac is an imaging indicator of pre-operative tumor rupture, the definitive diagnosis of tumor rupture implying stage III disease and hence need for abdominal radiation has to be made at the time of laparotomy. Tumor rupture is not an indication for secondary nephrectomy in the current COG trials.

- Option B is NOT correct. Though imaging has high specificity for detection of lymph node metastasis in Wilms tumor, the sensitivity is low. Definitive diagnosis of lymph node metastasis has to be made at pathological evaluation of surgically sampled lymph nodes. Bulky retroperitoneal lymphadenopathy is not a contraindication to primary nephrectomy in the current COG trials.

- Option C is CORRECT. Tumor thrombus extending above the hepatic veins is one of the few indications for pre-operative chemotherapy prior to nephrectomy in the current COG studies. This is due to high intra-operative morbidity caused by caval thrombus.

- Option D is NOT correct. Tumor size alone is not an indication for secondary nephrectomy. Surgical evaluation at initial presentation provides accurate information regarding staging and presence of anaplasia and is the preferred therapy approach in the current COG trials.
In the image shown below, which of the following imaging findings warrants chemotherapy prior to nephrectomy?


In the above figures, the arrows most likely depict

- Options A, C, D, and E are NOT correct. There are no findings that suggest that this uptake is pathologic.

- Option B is CORRECT.
  - In figure I, activity in the mid-chest that clears after drinking water represents swallowed salivary secretions within the esophagus.
  - In figure 2, the activity seen in the anterior mid-chest correlates with normal thymus gland on CT and represents physiologic thymic uptake. The mechanism is not entirely clear, but is likely related to uptake of iodine via thymic sodium-iodide symporter with iodine concentration in Hassall’s bodies. Thymic uptake tends to become more evident on delayed imaging, with a therapeutic dose, in younger patients, and with less residual or metastatic thyroid tissues.

In the above figures, the arrows most likely depict


What is the major mechanism of uptake of I-131 MIBG in neuroblastoma cells?

A. Specific active transport via norepinephrine transporter
B. Non-specific passive transport
C. Retinoic acid receptor
D. ALK tyrosine kinase receptor
E. GD2 receptor

Option A is CORRECT. The majority of MIBG uptake in neuroblastoma cells is through active transport (Uptake-1) via norepinephrine transporter (NET), which is approximately 50 times more efficient than passive transport. 90% of neuroblastomas express NET.

Option B is NOT correct. Norepinephrine is also taken into cells by passive, non-specific diffusion (Uptake-2) that is energy-independent, unsaturable, and results in low-level norepinephrine accumulation.

Option C is NOT correct. Retinoic acid receptors mediate the differentiation and growth arrest effects of retinoic acid on neuroblastoma cells.

Option D is NOT correct. Surface glycolipid molecule disialoganglioside (GD2) is the target receptor of GD-2 directed antibodies, which are investigational immunotherapy agents against neuroblastoma.

Option E is NOT correct. ALK tyrosine kinase receptor is the target for investigational ALK inhibitors.

Contrast enhanced ultrasound is a valuable biomarker of tumor _________.

A. Hypoxia
B. Cell proliferation
C. Apoptosis
D. Metastasis
E. Angiogenesis
Contrast enhanced ultrasound is a valuable biomarker of tumor ____________.

- Option A is NOT correct. CEUS cannot measure tumor oxygen levels. Tumor hypoxia may be measured by BOLD MRI or PET imaging.
- Option B is NOT correct. CEUS does not detect cell proliferation. Tumor cell proliferation may be measured by diffusion weighted MRI or PET imaging.
- Option C is NOT correct. Apoptosis may be measured by diffusion weighted MRI or nuclear imaging, but not by CEUS.
- Option D is NOT correct. CEUS is not a good method of detecting tumor metastasis because it cannot be used as a screening tool. Tumor metastasis is assessed by whole body and cross-sectional imaging techniques.
- Option E is CORRECT. Because ultrasound contrast agents behave like red blood cells in the human circulation they are good surrogate markers of tumor blood flow and angiogenesis.

Contrast enhanced ultrasound is a valuable biomarker of tumor ____________.

- Fass L. Imaging and cancer. Mol Oncol. 2008;2:115-152

Ultrasound contrast agents are good surrogate markers of tumor blood flow because:

A. They diffuse across the vascular membrane.
B. They adhere to the vascular endothelium.
C. The microspheres approximate the size of a red blood cell and flow freely throughout the circulation.
D. They only flow into tumors.
E. They are metabolized by tumor cells.

Ultrasound contrast agents are good surrogate markers of tumor blood flow because:

- Option A is NOT correct. Unlike CT and MR contrast agents which are composed of very small particles that diffuse freely across the vascular membrane, ultrasound contrast agents are composed of larger microspheres that cannot diffuse and, therefore, remain within the vascular space.
- Option B is NOT correct. The clinically available ultrasound contrast agents are not targeted agents and do not adhere to cells.
- Option C is CORRECT. Ultrasound contrast agents range in size from 2 to 4.5 microns which is about the size of a red blood cell. Ultrasound contrast agents will follow the same circulatory route as normal blood cells.
- Option D is NOT correct. Ultrasound contrast agents flow freely throughout the body, following the normal circulatory route of red blood cells.
- Option E is NOT correct. The outer shell of ultrasound contrast agents, whether a phospholipid or protein, is metabolized by normal metabolic routes, but not metabolized by tumor cells. The inner gas is then exhaled by the lungs.
Ultrasound contrast agents are good surrogate markers of tumor blood flow because:


An 18-year-old with Hodgkin lymphoma undergoes an FDG PET scan after initial chemotherapy. What Deauville score should be given?

- A. Deauville 1
- B. Deauville 2
- C. Deauville 3
- D. Deauville 4
- E. Deauville 5

Option E is CORRECT. On this scan, a focus of uptake is seen in the mediastinum with intensity markedly increased compared to liver, which would give a score of Deauville 5.

- Deauville 1 = no residual uptake above the background.
- Deauville 2 = residual uptake less than or equal to the mediastinum.
- Deauville 3 = residual uptake greater than mediastinum, but not greater than liver.
- Deauville 4 = residual uptake moderately increased compared with liver.
- Deauville 5 = residual uptake markedly increased compared with liver or new sites of disease.
A 13-year-old boy with neuroblastoma undergoes an I-123-MIBG scan after initial chemotherapy. What Curie score should be given?

A. 30  
B. 21  
C. 7  
D. 3  
E. 0

Option B is CORRECT.

- A score of 30 would require the presence of soft tissue disease and diffuse involvement of the entire skeleton. On the scan, no soft tissue disease is seen and a few areas of the skeleton are spared (most notably the forearms and distal legs).
- Scores of 7 and 3 would indicate less extensive skeletal involvement than seen on the scan.
- A score of 0 indicates a normal scan. The presence of skeletal uptake is NOT normal on an MIBG scan.

Based on RECIST 1.1 criteria, which of the following lesions would be an appropriate target lesion on CT?

A. Low attenuation liver lesion measuring 0.8 cm in maximum diameter  
B. Lymph node in the right hilum measuring 1.3 cm in short axis diameter  
C. Subcarinal mass measuring 2.5 cm in maximum diameter  
D. Lucent bone lesion, without a soft tissue component, measuring 1.9 cm in maximum diameter  
E. A right renal simple cyst measuring 3.2 cm in diameter
Based on RECIST 1.1 criteria, which of the following lesions would be an appropriate target lesion on CT?

- Option A is NOT correct. A target lesion must measure over 1 cm in diameter.
- Option B is NOT correct. In order to be target lesions, lymph nodes, must measure over 1.5 cm in short axis diameter.
- Option C is **CORRECT**. A target lesion must be over 1 cm in diameter.
- Option D is NOT correct. In order to be a target lesion, a bone lesion must have an identifiable soft tissue component.
- Option E is NOT correct. Simple cysts cannot be included as target lesions because they are not a part of the malignant process.

**A 3-year-old girl is newly diagnosed with neuroblastoma. CT shows a large retroperitoneal mass encasing the aorta, the celiac axis, the root of the superior mesenteric artery, and the left renal artery. No distant metastatic disease is detected.**

Based on the International Neuroblastoma Risk Group staging system, what stage would this patient be assigned?

A. L1
B. L2
C. M
D. MS

- Option A is NOT correct. Encasement of the SMA and other vessels is an “Imaged Defined Risk Factor” which upstages the patient beyond L1 disease.
- Option B is **CORRECT**. The disease is localized, and the vascular encasement is an IDRF which defines this as L2 disease.
- Option C is NOT correct. Distant metastases are present in stage M disease.
- Option D is NOT correct. Stage MS patients must be under 18 months of age and have metastatic disease limited to bone marrow, skin and liver.

A 3-year-old girl is newly diagnosed with neuroblastoma. CT shows a large retroperitoneal mass encasing the aorta, the celiac axis, the root of the superior mesenteric artery, and the left renal artery. No distant metastatic disease is detected. Based on the International Neuroblastoma Risk Group staging system, what stage would this patient be assigned?


**What is the greatest source of artifact on this diffusion weighted image?**

- Option A is **NOT** correct. Chemical shift artifact is a spatial uniform shift.
- Option B is **CORRECT**. Distortion is a spatially varying shift. Note in the image the left side of the patient, particularly the left anterior abdominal wall is the most shifted.
- Option C is **NOT** correct. Fat suppression is actually quite good in this image.
- Option E is **NOT** correct. Pin cushion is a geometric distortion that occurs in large field of view imaging and manifests most in the corners of the image.

Which of the following is directly measured in perfusion MRI:

A. Pharmacokinetic parameters
B. Contrast agent concentration
C. MRI signal intensity
D. Tumor relaxation rates
E. Blood flow

Which of the following is directly measured in perfusion MRI:

• Option A is NOT correct. Pharmacokinetic parameters are derived indirectly and are based on a number of assumptions, including a pharmacokinetic model.
• Option B is NOT correct. Contrast agent concentration is indirectly assessed through the MR signal and is based on an assumption of low contrast agent concentration.
• Option C is CORRECT. MRI signal intensity is directly measured.
• Option D is NOT correct. Relaxation rates are not directly measured but inferred from changes to the MRI signal intensity.
• Option E is NOT correct. Blood flow is not directly measured, though a blood pool volume can be indirectly assessed.

With regard to the assessing disease bulk in Hodgkin Lymphoma, which of the following measurements DOES NOT qualify as bulky disease?

A. Cranio/caudal measurement of cervical adenopathy = 7.0 cm
B. Transthoracic ratio of greater than 1/3, measured on PA Upright Chest
C. Conglomerate of small cervical lymph nodes
D. Mediastinal mass of 10 cm in transverse dimension

With regard to the assessing disease bulk in Hodgkin Lymphoma, which of the following measurements DOES NOT qualify as bulky disease?

- Options A, B, and D are NOT correct. All of these measurements fulfill criteria used by the Children's Oncology Group to establish bulk disease and are based on the Cotswold Modification of the Ann Arbor criteria. Note that the recent adult criteria established by the International Working Group use a CT measurement of 10 cm. The COG has modified this, and uses a measurement of > 6 cm account for the smaller volumes of bulky disease found in children, and allow craniocaudal measurements to be used.

- Option C is CORRECT. Small lymph node conglomerates do not meet the criteria for bulk disease.

Using the Deauville 5-point scale of response assessment in Hodgkin lymphoma, which of the options below best describes this patient’s response:

- Deauville 2: < or = mediastinal blood pool
- Deauville 3: > mediastinal blood pool but < or = liver
- Deauville 4: Moderate increase compared to liver
- Deauville 5: > 75% shrinkage of the mediastinal mass

With regard to the assessing disease bulk in Hodgkin Lymphoma, which of the following measurements DOES NOT qualify as bulky disease?


Using the Deauville 5-point scale of response assessment in Hodgkin lymphoma, which of the options below best describes this patient’s response?

- Answer C is CORRECT. Based on the criteria proposed at the 2009 Interim-PET workshop in Deauville, France a 5-point visual scale was proposed that incorporates the use of internal reference standards to aid in the semi-quantitative visual assessment of interim PET results. Using these criteria, only answer C is correct. The residual uptake shown is clearly greater than both mediastinal blood pool and liver, negating A and B. The image shown could be interpreted as either mild/moderate uptake over liver (Deauville 4) or significant uptake relative to liver (Deauville 5). However, in answer D the Deauville 5 choice refers to an anatomic measurement and % shrinkage, which is incorrect. The Deauville criteria refer only to post-therapy FDG-PET assessment.
Using the Deauville 5-point scale of response assessment in Hodgkin lymphoma, which of the options below best describes this patient’s response?