Nuclear Radiology
In-Training Test Questions
for Diagnostic Radiology Residents

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1891 Preston White Drive -- Reston, VA 20191-4326 -- 703/648-8900 -- www.acr.org

1. Concerning infection imaging with In-111 labeled leukocytes, which one is CORRECT?

   A. Uptake is dependent on regional blood flow.
   B. It is insensitive for the detection of inflammatory bowel disease.
   C. Transient pulmonary uptake clears within 15 minutes post-injection.
   D. It is more sensitive than Ga-67 citrate imaging for detection of Pneumocystis carinii pneumonia (PCP).

Rationales**:**

A. **Correct**. While not the sole determinant of uptake, the uptake of In-111 labeled leukocytes is dependent upon regional blood flow. For example, a walled-off abscess without a direct blood supply will not accumulate In-111 labeled leukocytes, and may appear as a photopenic defect.

B. *Incorrect*. In-111 WBC imaging is very sensitive for active inflammatory bowel disease. It has advantages over Ga-67 citrate imaging in this clinical setting, as a result of the absence of normal bowel uptake of the tracer.

C. *Incorrect*. Transient lung uptake can be seen 4 hours after injection or even longer, sometimes making the diagnosis of pulmonary infection difficult.

D. *Incorrect*. In-111 WBC's are less sensitive than Ga-67 citrate for detecting chest infections, such as PCP. As a result, Ga-67 citrate imaging is preferred in the clinical settings of suspected chest infection or in immuno-compromised patients presenting with fever of unknown origin.

Citations:

"Nuclear Medicine" Henkin, et al, Mosby, 1996.

2. Which ONE of the following sets of I-123 thyroid scintigraphy findings and history of radiation exposure is associated with the LOWEST relative risk for thyroid carcinoma?

A. Multiple cold nodules with previous head and neck irradiation.
B. Multiple cold nodules without prior head and neck irradiation.
C. Solitary cold nodule without prior head and neck irradiation.
D. Solitary cold nodule with previous head and neck irradiation.

Rationales**:**
A. *Incorrect*. This combination of scan findings and history is associated with the *highest* relative likelihood of malignancy of all those listed, in the range of 40%.
B. **Correct**. The finding of multiple cold nodules without prior radiation exposure is consistent with a non-specific multinodular goiter, and carries a risk of underlying malignancy of only ~ 5%.
C. *Incorrect*. While the absence of prior head and neck irradiation reduces the likelihood of malignancy, the prevalence of malignancy in patients presenting with solitary cold thyroid nodules is still in the range of about 15-20% overall.
D. *Incorrect*. The history of prior head and neck irradiation significantly increases the likelihood of malignancy in a patient with a solitary cold nodule, with the likelihood being somewhere in the range of 30-40%, slightly lower than for option A.

Citations:
Mettler FA and Guiberteau MJ: Essentials of Nuclear Medicine Imaging, 4th edition.

3. Which one of the following is NOT a normal site of F-18 fluorodeoxyglucose (FDG) localization?

A. Salivary glands
B. Gallbladder
C. Colon
D. Kidneys

Rationales**:**
A. *Incorrect*. Symmetrical salivary gland uptake is a normal finding on FDG PET imaging.
B. **Correct**. The gallbladder is not a normal site of FDG localization. Increased uptake in the gallbladder suggests the presence of cholecystitis or a neoplastic process within the gallbladder.
C. *Incorrect*. While variable in intensity and extent, colonic uptake of FDG is normal.
D. *Incorrect*. Renal uptake is almost always visualized on FDG PET studies. Renal excretion into the collecting systems and bladder is also seen in the majority of cases.

4. Concerning the presence of hydrolyzed reduced Tc-99m in a dose of Tc-99m MDP (methylene diphosphonate) administered intravenously for a bone scan, which is CORRECT?

A. It results in thyroid visualization.
B. It can be identified using a dose calibrator.
C. It is more likely to occur in the presence of excess stannous ion.
D. It occurs more commonly when multidose vials are used.

Rationales:
A. *Incorrect*. Hydrolyzed reduced technetium-99m is a colloidal impurity that results in hepatic and reticuloendothelial visualization, not thyroid visualization, which is typical of the presence of free pertechnetate as an impurity.
B. *Incorrect*. Only chromatography pre-imaging will detect this radiopharmaceutical impurity.
C. *Incorrect*. On the contrary, Sn(II)ion is a reducing agent protecting MDP from hydrolysis.
D. **Correct**. The introduction of air into a multidose MDP vial is the most frequent cause of this hydrolyzed technetium-99m contaminant. The more violations of the vial, the more likely air will be introduced.

Citations:
Thrall et.al. ED. Nuclear Medicine. The Requisites Chapter 6, pp 110-112. Mosby, 2001.

5. Concerning treatment of intractable pain from widespread metastatic bone lesions with Metastron® (Sr-89) and Quadramet® (Sm-153), which one is CORRECT?

   A. Both can be imaged using a gamma camera to assess the biodistribution of the therapeutic dose.
   B. The longer half-life of Metastron (50 days) versus Quadramet (1.9 days) provides a superior therapeutic effect.
   C. Because of the highly energetic beta particles produced by both agents, a lead syringe shield is employed during dose administration.
   D. Recovery from bone marrow toxicity is faster following Quadramet administration.

Rationales:

A. *Incorrect*. Metastron is a pure beta emitter. The absence of an imagable gamma photon precludes verification of bone lesion uptake. By contrast, Sm-153 has an imagable gamma photon energy of 103 keV, permitting bone scintigraphy to be performed in conjunction with the therapeutic procedure.

B. *Incorrect*. While it is true that the half-life of Metastron is significantly longer, resulting in more prolonged lesion irradiation, the clinical efficacy of both treatments are quite similar.

C. *Incorrect*. Due to bremsstrahlung production of high energy photons when high atomic number material (eg. lead) is used for shielding, acrylics are the preferred material for handling of these materials. Materials with lower atomic numbers, such as plastic or acrylics make ideal shields. In addition, bremsstrahlung production is proportional to the atomic number, which is lower for these materials.

D. **Correct**. The major limitation of both therapies is myelosuppression. Metastron causes 15-30% drops in the platelet and WBC counts from pre-injection values, and Quadramet, 40-50%. However, 8-12 weeks are required for full bone marrow recovery from Metastron, versus only 6-8 weeks for Quadramet.

Citations:

Metastron package insert. Arlington Heights, IL: Amersham Healthcare, 1993. REF: Weiner RE, Thakur ML. Therapeutic Agents. In: Sandler MP et al., eds/ Diagnostic Nuclear Radiology, 4th ed. Baltimore: Williams & Wilkins, 2003:112.

6. Reduced occipital lobe glucose metabolism on F-18 FDG (fluorodeoxyglucose) cerebral PET imaging is MOST common in which one of the following progressive dementias?

A. Alzheimer's
B. Pick's
C. Parkinson's
D. Lewy body

Rationales:

A. *Incorrect*. Alzheimer's dementia at the earliest stages is associated with temporoparietal and later frontal lobe FDG hypometabolism, with typical sparing of sensorimotor and visual cortex (occipital lobe).

B. *Incorrect*. Pick's disease is a degenerative dementia predominately involving frontal and temporal lobes. Frontal hypometabolism precedes development of temporal hypometabolism. The visual cortex is generally uninvolved.

C. *Incorrect*. Parkinson's dementia is a late manifestation of a neurodegenerative disease, primarily affecting the basal ganglia. There is occasional involvement of the occipital cortex, although temporoparietal hypometabolism pattern similar to that of Alzheimer's, but with additional striatal hypometabolism, is a more common FDG pattern.

D. **Correct**. Decreasing cognitive function accompanied by visual disturbance including hallucinations is common presentation in diffuse Lewy body disease (DLBD) which is becoming more widely recognized and accounts for up to 20% of all autopsy confirmed dementias. Medical and lateral occipital lobe FDG metabolism is more severely reduced in DLBD than other dementias. When identified on FDG PET images, cholinergic therapy has been useful in controlling the disease.

Citations:

Silverman D. Brian 18 F-FDG PET in the diagnosis of neurodegenerative dementias. Journal of Nuclear Radiology. 2004, 45: 594-607.Van Heertum et al. Single photon emission CT and position emission tomography in the evaluation of neurologic disease. Radiology Clinics of North America. Vol 39, number 5, pp 1014-1019, September, 2001.

7. Concerning the biodistribution of Indium-111 ibritumomab tiuxetan (Zevalin®) 48 hours following intravenous administration, which one is CORRECT?

   A. Persistent blood pool activity indicates the presence of a human anti-mouse antibody (HAMA) response.
   B. Absence of bone marrow activity indicates > 25% marrow infiltration by lymphoma.
   C. Renal activity less intense than hepatic is indicative of altered biodistribution.
   D. Hepatic activity more intense than bowel uptake is normal.

Rationales:

A. *Incorrect*. The cardiac blood pool activity gradually decreases with time as Zevalin is distributed to the other organs and a small component is excreted. Persistent but decreased blood pool activity is normal at 48 hours. The development of a HAMA response occurs in < 2% of patients. More rapid clearance of the Zevalin antibody can occur with the development of a HAMA response, and hence, a shorter circulation time.

B. *Incorrect*. The Zevalin therapeutic regime should not be given to patients with greater than or equal to 25% lymphoma marrow involvement. Altered biodistribution is suggested with rapid blood pool clearance and increased marrow uptake.

C. *Incorrect*. Normal renal activity with Indium-111 Zevalin is generally manifested as faint activity (moderately low to very low activity), which is much less intense than hepatic uptake. Altered renal biodistribution is present if renal activity greater than liver is demonstrated on the posterior images.

D. **Correct**. Bowel activity is common and normal. However, normal gastrointestinal biodistribution is activity that is less intense than liver and decreases over time (moderately low to very low intensity). Bowel activity more intense than hepatic uptake is indicative of altered biodistribution.

Citations:

IDEC Pharmaceuticals Medical Information and Communication “Zevalin Radioimmunotherapy in Non-Hodgkin’s Lymphoma”; pages 2-3 to 2-8IDEC Pharmaceuticals Medical Information and Communication “Zevalin Radioimmunotherapy in Non-Hodgkin’s Lymphoma,” page 2-6IDEC Pharmaceuticals Medical Information and Communication “Zevalin Radioimmunotherapy in Non-Hodgkin’s Lymphoma”IDEC Pharmaceuticals Medical Information and Communication “Zevalin Radioimmunotherapy in Non-Hodgkin’s Lymphoma,” pages 2-6, 2-11.

8. Which of the following statements about Y-90-ibritumomab tiuxetan (ZevalinR) radioimmunotherapy (RIT) for indolent non-Hodgkin's lymphoma is TRUE?

A. It targets CD-15 receptors on immature B cells.
B. Tc-99m labeled ZevalinR is used for imaging prior to therapy.
C. Unlabeled rituximab (RituxanR) must be intravenously infused before therapy.
D. Bone marrow involvement of less than or equal to 50% is a prerequisite.

Rationales:

A. *Incorrect*. Y-90 ZevalinR targets CD-20 receptors on mature B-cells.

B. *Incorrect*. Pre-RIT imaging is performed using In-111 labeled ZevalinR. ZevalinR is not available labeled with Tc-99m.

C. **Correct**. Rituximab is given prior to administration of Y-90 ZevalinR to deplete binding sites on circulating B-cells, which would otherwise bind to the radiopharmaceutical and reduce the effectiveness of the RIT.

D. *Incorrect*. Bone marrow involvement must be less than 25%, not 50%.

Citations:

Biodistribution and dosimetry results from a phase III prospectively randomized controlled trial of Zevalin radioimmunotherapy for low-grade, follicular, or transformed B-cell non-Hodgkin's lymphoma. Crit Rev Oncol Hematol. 2001 Jul-Aug;39(1-2):181-94.PMID: 11418315.

9. Which of the following statements regarding F-18-fluorodeoxyglucose PET imaging in lymphoma is TRUE?

A. It has the same sensitivity for the detection of Hodgkin's disease and non-Hodgkin's lymphoma.
B. Higher standardized uptake values are associated with mucosa-associated lymphoid tumor (MALT) lymphoma than with other cell types.
C. It can be used to assess the effectiveness of chemotherapy after as few as two treatment cycles.
D. While it is more sensitive than Ga-67 citrate imaging for the primary staging of lymphoma, it is less sensitive for the detection of recurrent disease.

Rationales:

A. *Incorrect*. While both Hodgkin's disease (HD) and non-Hodgkin's lymphoma (NHL) are accurately assessed using F-18 FDG PET, HD has significantly higher sensitivity and specificity than NHL overall. This difference is due to the fact that low-grade NHLs demonstrate lower FDG uptake.

B. *Incorrect*. In one study of 10 patients, MALT lymphoma did not reveal any significant F-18 FDG uptake. While other studies have produced variable results, nevertheless, the FDG avidity for MALT lymphomas is overall significantly lower than for many other cell types.

C. **Correct**. FDG PET can be used with high positive predictive value to assess the response to chemotherapy, even after only one or two cycles of treatment.

D. *Incorrect*. FDG PET has been demonstrated to be more sensitive than Ga-67 citrate scintigraphy for the diagnosis, staging and re-staging of both HD and NHL.

Citations:

Israel O, Keidar Z, Bar-Shalom R. Positron Emission Tomography in the Evaluation of Lymphoma. Semin Nucl Med 34:166-179, 2004.

10. Which of the following statements about agreement states is CORRECT?

    A. They are states that agree to allow the Nuclear Regulatory Commission (NRC) to regulate radioactive by product material within their boundaries.
    B. They are states that agree to regulate radioactive by product material within their borders on behalf of the NRC.
    C. They are permitted to have less stringent regulations than the NRC.
    D. A state can become an agreement state without prior notification of the NRC.

Rationales:

A. *Incorrect*. Agreement states regulate by-product material within their borders in place of the NRC.

B. *Correct.*

C. *Incorrect*. Regulations in agreement states must be as stringent as NRC regulations, and can be more stringent.

D. *Incorrect*. Agreement states must demonstrate to the NRC that they have the capabilities to assume the NRC's mission within their boundaries, and that the intended regulations are consistent with NRC rules and regulations and are as strict or more so.

Citations:

Wilson, Michael A., editor, Textbook of Nuclear Medicine. Lippincott-Raven, Philadelphia, PA, 1998.