Section XII – Nuclear Radiology

235. You are shown I-123 thyroid images (Figure 1) obtained from a 54-year-old woman with signs and symptoms of hyperthyroidism. Which of the following is the MOST LIKELY 24-hour I-123 thyroid uptake value for this patient?

A. 5%
B. 15%
C. 30%
D. 60%

Findings:
There is a hyperfunctioning nodule in the superior aspect of the isthmus, with associated partial suppression of uptake by the remainder of the thyroid gland, which also appears inhomogeneous.

Rationale:
A: The images depict a multinodular goiter (MNG) with a dominant hyperfunctioning nodule in the isthmus, with probable partial suppression of uptake by the remainder of the gland. Given that the patient is clinically hyperthyroid, this case would represent a toxic nodular goiter. The 24 hour RAIU in individuals with toxic nodular goiter is typically in the 20-30% range (upper-normal to mildly elevated). An uptake of 5% would be typical for patients with primary/secondary hypothyroidism, subacute thyroiditis in the acute phase, struma ovarii, or in some instances, excess exogenous iodine intake or administration of thyroid hormone. This value would not be consistent with the combination of the images and clinical setting of this case.

B: Again, the images depict a multinodular goiter (MNG) with a dominant hyperfunctioning nodule in the isthmus, with probable partial suppression of uptake by the remainder of the gland. Given that the patient is clinically hyperthyroid, these findings are consistent with a toxic nodular goiter. The 24 hour thyroid uptake in individuals with toxic nodular goiter is typically in the 20-30% range (upper-normal to mildly elevated). An uptake of 15% is normal, which would not typically occur in this clinical setting of a clinically hyperthyroid patient.

C: The images in this case are consistent with toxic nodular goiter, given the history of a clinically hyperthyroid patient. The 24 hour thyroid uptake in individuals with toxic nodular goiter is typically in the 20-30% (upper-normal to mildly elevated), and is generally lower than the uptake values commonly observed in Graves' disease (diffuse toxic goiter).

D: In the setting of a hyperthyroid patient, a 24 hour thyroid uptake of 60% or higher is much more often associated with Graves' disease than toxic nodular goiter, the latter being present in this case.
236. You are shown serial dynamic images (Figure 2) from a Tc-99m-tagged RBC scan obtained from a 55-year-old man presenting with bright red blood per rectum. Based on the findings demonstrated, which major branch vessel of the aorta is MOST LIKELY involved?

A. Celiac axis  
B. Superior mesenteric artery  
C. Inferior mesenteric artery  
D. None; there is no evidence of hemorrhage.

**Findings:**
Dynamic images from a Tc-99m Tagged RBC scintigraphy study demonstrate abnormal tracer activity originating in the left lower quadrant, corresponding to the region of the distal descending colon or sigmoid colon. This activity increases over time, conforms to the large bowel, and moves antegradely/retrograde, confirming the presence of a distal colonic bleed. Stable activity note in the left upper quadrant probably represents activity within the left kidney (similar, less striking finding also noted on the right), of no clinical significance.

**Rationale:**
A: The abnormal activity in this exam corresponds to the left colon (distal descending or sigmoid). The inferior mesenteric artery (IMA) supplies the portions of the large intestine from the splenic flexure to the superior aspect of the rectum, which includes the descending colon, the sigmoid colon, and part of the rectum. By contrast, the celiac artery supplies the liver, stomach, abdominal portion of distal esophagus, spleen and superior half of both the duodenum and pancreas.

B: Again, the bleeding site in this case arises in the distal descending or sigmoid colon, which are supplied by the inferior mesenteric artery. The superior mesenteric artery supplies the intestine from the distal portion of duodenum through two-thirds of the transverse colon, as well as the pancreas.

C: The inferior mesenteric artery (IMA) supplies the site of origin of hemorrhage in this case, which arises in the distal descending colon or sigmoid colon. The IMA supplies the distal large intestine, from the splenic flexure to the superior portion of the rectum, which includes the descending colon, the sigmoid colon, and part of the rectum.

D: The images show abnormal tracer activity originating in the left lower quadrant. This activity increases over time, conforms to large bowel, and moves both antegradely and retrogradely, confirming the presence of a lower GI bleed. This is not a normal study.
237. You are shown serial posterior images (Figure 3) of the abdomen and pelvis obtained in a young child. Which of the following is the MOST LIKELY diagnosis?

A. Nonfunctioning right kidney
B. Distal left ureteral obstruction
C. Mild left vesicoureteral reflux
D. Severe left vesicoureteral reflux

Findings:
There is delayed appearance of vesicoureteral reflux on the left, extending proximally to the left renal pelvis, which is dilated.

Rationale:
A: This study is a direct radionuclide cystogram, as indicated by the presence of radiopharmaceutical only in the bladder initially, where it was administered. There is reflux of radiopharmaceutical into the left renal collecting system, with a dilated left renal pelvis also demonstrated. The absence of visualization of activity within the right renal collecting system reflects the absence of right-sided vesicoureteral reflux, not impaired right renal function, since this is not an antegrade (intravenous) renogram study.

B: This study is a direct radionuclide cystogram, as indicated by the presence of radiopharmaceutical only in the bladder initially, where it was administered. There is relatively prompt appearance of reflux of radiopharmaceutical into the left renal collecting system, with a dilated left renal pelvis also demonstrated. The presence of activity within the left renal collecting system is the result of reflux into the left ureter, not antegrade secretion from the left kidney with distal obstruction.

C: This study is a direct radionuclide cystogram, as indicated by the presence of radiopharmaceutical only in the bladder initially, where it was administered. There is relatively prompt reflux of radiopharmaceutical into the left renal collecting system, with a dilated left renal pelvis also demonstrated. Since the reflux extends proximally to the level of the renal pelvis and is also associated with renal pelvic dilatation, this is a case of severe, not mild, reflux.

D: This study is a direct radionuclide cystogram, as indicated by the presence of radiopharmaceutical only in the bladder initially, where it was administered. There is relatively prompt reflux of radiopharmaceutical into the left renal collecting system, with a dilated left renal pelvis also demonstrated. These findings are consistent with severe reflux.
238. You are shown images from a ventilation-perfusion (V/Q) scintigraphy study (Figure 4) performed in an adult patient. Which of the following is the MOST LIKELY diagnosis?

A. Pulmonary embolism
B. Swyer-James syndrome
C. Takayasu’s arteritis
D. Postradiation therapy findings

Rationale:
A: Pulmonary embolism involving the main pulmonary artery would most likely result in a whole-lung V/Q mismatch, not whole-lung matching findings, as are illustrated in this case.
B: Swyer-James Syndrome results from presumed post-infectious unilateral bronchiolitis obliterans, and may produce a whole-lung matching abnormality, as demonstrated in this case. The decreased ventilation in the involved lung results in reflex vasoconstriction, producing matching ventilation and perfusion findings.
C: Takayasu's arteritis may involve the pulmonary arteries or other great vessels, without affecting the airways, and may result in a whole-lung V/Q mismatch, not whole-lung matching findings, as are illustrated in this case.
D: Radiation therapy causes an obliterative end-arteritis, without significant effects on the airways, and therefore may result in a segmental or even whole-lung V/Q mismatch, not whole-lung matching findings, as are illustrated in this case.
You are shown radionuclide images of the abdomen (Figure 5) obtained prior to the therapeutic administration of Y-90-labeled microspheres for treatment of hepatic malignancy. The patient has not undergone prior surgery. Which one of the following procedures was MOST LIKELY performed?

A. Tc-99m MAA injected via a right hepatic artery catheter
B. Tc-99m MAA injected via a proper hepatic artery catheter
C. Tc-99m sulfur colloid injected via a right hepatic artery catheter
D. Tc-99m sulfur colloid injected via a proper hepatic artery catheter

Findings:
Tc-99m MAA was injected via hepatic artery catheter into the right hepatic artery. There is no visualization of activity within the left hepatic lobe.

Rationale:
A: Intra-arterial administration of Tc-99m MAA is used to document the vascular distribution at the time of injection and assess tracer arteriovenous shunting to the lungs and GI tract. If there is > 20% shunting to the lungs, treatment with Y-90 microspheres is contraindicated. If >10% pulmonary shunting is detected, the therapeutic radionuclide dose may be decreased to prevent radiation pneumonitis. If significant gastrointestinal activity is seen, embolization(s) of these vessels is indicated prior to Y-90 therapy. In this case, the distribution of activity within the liver is consistent with visualization of the right hepatic lobe only. In the absence of previous hepatic resection, this finding is most likely the result of injection of the radiotracer into the right hepatic artery.
B: The images demonstrate activity only in the right lobe of the liver, therefore, unless the patient has undergone prior left hepatic lobe resection or the catheter is not correctly positioned, this option is incorrect.
C: The tracer was injected into the right hepatic artery, but MAA (macroaggregated albumin), rather than sulfur colloid, is typically used for this study.
D: Again, only the right hepatic lobe is visualized, which would not be expected if the above procedure were performed. In addition, Tc-99m MAA is usually used for this procedure, not Tc-99m sulfur colloid.
240. You are shown baseline posterior images and renogram curves (Figures 6 and 7) from a Tc-99m MAG3 renal scan and further images and curves (Figures 8 and 9) obtained following an intervention in a patient presenting with left flank pain. Which of the following is the MOST LIKELY diagnosis?

A. Left renal artery stenosis  
B. Right renal artery stenosis  
C. **Left ureteropelvic junction obstruction**  
D. Left vesicoureteral reflux

**Findings:**
The baseline study demonstrates left hydronephrosis with high-grade drainage impairment at the left ureteropelvic junction, which persists on an upright post-void image. The renogram curve demonstrates a progressive accumulation pattern on the left. The post-furosemide images demonstrate only minimal clearance from the left collecting system, with a clearance half-time > 30 minutes, consistent with high-grade left UPJ obstruction.

**Rationale:**
A: The baseline study demonstrates left hydronephrosis with high-grade drainage impairment at the level of the left ureteropelvic junction (UPJ), with an associated progressive accumulation pattern noted on the left renogram curve. The intervention, intravenous administration of 40 mg of furosemide (Lasix) produced no significant change, consistent with high-grade left UPJ obstruction. The baseline findings would not represent an indication for Captopril administration, nor are the findings suggestive of renal artery stenosis on either side.

B: The baseline study demonstrates left hydronephrosis with high-grade drainage impairment at the level of the left ureteropelvic junction (UPJ), with an associated progressive accumulation pattern noted on the left renogram curve. The intervention, intravenous administration of 40 mg of furosemide (Lasix) produced no significant change, consistent with high-grade left UPJ obstruction. The baseline findings would not represent an indication for Captopril administration, nor are the findings suggestive of renal artery stenosis on either side.

C: The study demonstrates left hydronephrosis, with high-grade drainage impairment at the left UPJ, which does not respond to furosemide administration, consistent with high-grade obstruction at the left UPJ.

D: There is left hydronephrosis, as discussed above, but there is no activity noted in the left ureter, and no other indication of vesicoureteral reflux, such as early excretion followed by delayed reaccumulation of activity within the left collecting system. If reflux were suspected, a direct radionuclide cystogram would be the most appropriate radionuclide procedure to perform.
241. You are shown stress and rest images (Figure 10) from a TI-201 chloride/Tc-99m sestamibi dual-isotope myocardial perfusion study performed in a thin 50-year-old woman presenting with atypical chest pain. Which of the following is the MOST LIKELY etiology for the findings demonstrated?

A. Ischemia in the left anterior descending coronary artery territory  
B. Infarction in the left anterior descending coronary artery territory  
C. Ischemia in the right coronary artery territory  
D. Breast attenuation artifact

Findings:
There is a large area of marked reversible ischemia involving the anterior and anteroseptal walls of the left ventricle, corresponding to the left anterior descending coronary artery territory.

Rationale:
A: The study demonstrates a large area of marked reversible ischemia involving the anterior and anteroseptal walls, which is most consistent with stress-induced ischemia in the left anterior descending (LAD) coronary artery territory.

B: The findings in the anterior and anteroseptal walls do correspond to the left anterior descending coronary artery territory, but the perfusion defect demonstrated is reversible, not fixed. Reversible stress-induced ischemia is consistent with ischemia without infarction. A fixed defect would be anticipated in the presence of an area of myocardial infarction.

C: Coronary artery vascular territories are somewhat variable, based on whether the patient has a right or left coronary dominant system. Nevertheless, involvement of the anterior and anteroseptal walls is highly predictive of involvement of the left anterior descending coronary artery. Ischemia in the distribution of the right coronary artery is more often associated with findings in the inferior, inferoapical, inferoseptal or inferolateral walls of the left ventricle, none of which are present in this case.

D: Breast attenuation artifact can result in apparent perfusion defects underlying the patient's breast tissue due to soft tissue attenuation artifact. When present, these defects may occur in the anterior, anteroseptal or anterolateral walls. However, breast attenuation artifact is more likely to be present both on stress and resting images, more often resulting in a fixed, rather than a reversible defect. In addition, the severity of the findings in this case are more striking than typically seen due to breast attenuation, especially given the history that the patient is not obese.
Anterior F-18 FDG maximum intensity projection (MIP) image of the chest, abdomen, and pelvis

Figure 11

242. You are shown an anterior maximum intensity projection (MIP) image (Figure 11) from an F-18 FDG PET scan performed in a patient with a history of previous total thyroidectomy for thyroid carcinoma. Which of the following is the MOST LIKELY clinical setting in which this study was performed?

A. Initial staging of medullary carcinoma of the thyroid
B. Routine 1-year postoperative follow-up of papillary carcinoma of the thyroid
C. Follow-up of focal findings in the chest demonstrated on I-131 whole-body scan
D. Evaluation for elevated serum thyroglobulin level with a negative I-131 whole-body scan

Findings:
The anterior FDG PET MIP image demonstrates a focal area of increased tracer uptake in the superior mediastinum to the left of midline.

Rationale:
A: FDG PET imaging is neither appropriate nor approved for use in the initial staging of medullary thyroid carcinoma, although it may be useful in the follow-up of selected patients with medullary carcinoma of the thyroid presenting with recurrent elevated serum calcitonin levels. Its main utility in thyroid carcinoma is in patients with well-differentiated thyroid carcinoma who present on follow-up evaluation after prior thyroidecctomy with elevated serum thyroglobulin levels without findings on I-131 or I-123 whole-body scintigraphy.
B: FDG PET imaging is not an appropriate routine follow-up examination for use in patients after thyroidecctomy for thyroid carcinoma. Its use is limited to the evaluation of patients with thyroid carcinoma derived from follicular elements (i.e., follicular, papillary or mixed papillary/follicular types only) who present on follow-up one or more years after thyroidecctomy with elevated serum thyroglobulin levels and negative I-131 whole-body scans.
C: FDG PET imaging is not indicated in patients with demonstrable residual or recurrent thyroid carcinoma on standard I-131 or I-123 whole-body scintigraphy. Such patients can be treated and/or followed based on the iodine imaging studies, without the need for further scintigraphic evaluation.
D: This is the appropriate setting for the use of FDG PET imaging in patients with thyroid carcinoma. The rationale for the study is that these patients have biochemical evidence of residual or recurrent disease that is not identifiable on radioiodine imaging, suggesting less well-differentiated disease, which is more likely to be FDG positive.
243. You are shown anterior and posterior whole-body images (Figure 12) and right and left lateral delayed static images of the chest (Figure 13) from a Tc-99m bone scan performed in a middle-aged woman. Based on the findings demonstrated, what is the MOST LIKELY diagnosis?

A. Metastatic bronchogenic carcinoma
B. Metastatic breast carcinoma
C. Multiple myeloma
D. Multiple fractures

**Findings:**
There are multiple focal areas of increased MDP uptake noted in the axial and proximal appendicular skeleton. In addition, there is a large, asymmetrical focal area of increased soft tissue uptake noted in the right breast, as well as a milder degree of diffusely soft tissue uptake and soft tissue swelling of the remainder of the right breast.

**Rationale:**
A: The skeletal findings are consistent with multiple skeletal metastases, for which bronchogenic carcinoma is a common etiology. However, the additional findings in the right breast of a focal, asymmetrical soft tissue mass and overall swelling and increased soft tissue uptake throughout the right breast suggest the presence of a right breast mass, possibly representing an inflammatory carcinoma. Thus, metastatic breast carcinoma is a more likely etiology for the overall findings in this case.

B: The skeletal findings are most consistent with multiple skeletal metastases, with multiple focal areas of increased tracer uptake demonstrated in the axial and proximal appendicular skeleton. In addition, there is a focal, rounded area of asymmetrically increased soft tissue uptake noted in the right breast, which is highly suspicious for uptake within a right breast mass, as well as a milder degree of diffusely increased soft tissue uptake and soft tissue swelling of the entire right breast, suggestive of the presence of inflammatory carcinoma. Thus, metastatic breast carcinoma is the most likely diagnosis.

C: The skeletal findings are consistent with multiple skeletal neoplastic lesions, for which multiple myeloma is a possible etiology, although the sensitivity of bone scintigraphy in multiple myeloma is significantly less than for a variety of skeletal metastatic lesions. In addition, skeletal metastases, either from breast carcinoma or bronchogenic carcinoma, are more common than multiple myeloma. Finally, the additional findings in the right breast of a focal, asymmetrical soft tissue mass and overall swelling and increased soft tissue uptake throughout the right breast suggest the presence of a right breast mass, possibly representing an inflammatory carcinoma. Thus, metastatic breast carcinoma is a much more likely etiology for the overall findings in this case.

D: The skeletal findings in this case are most consistent with multiple skeletal metastases or other malignancy. The distribution of the lesions is relatively random, though distributed in the axial and proximal appendicular skeleton, which is a typical for most skeletal metastases. Fractures most often occur in one or several adjacent sites, are more common in the more distal extremities than metastases, and when involving the ribs, usually demonstrate a linear distribution of focal lesions. In addition, it is unusual to observe fractures this numerous in widely separated locations. Furthermore, the additional findings in the right breast of a focal, asymmetrical soft tissue mass and overall swelling and increased soft tissue uptake throughout the right breast suggest the presence of a right breast mass, possibly representing an inflammatory carcinoma. Thus, metastatic breast carcinoma is a much more likely etiology for the overall findings in this case.
244. You are shown multiple planar images (Figure 14) from an In-111 DTPA radionuclide cisternogram. Which of the following statements is MOST consistent with the findings demonstrated in the images?

A. There is an obstructed ventriculoperitoneal shunt.
B. The findings are consistent with noncommunicating hydrocephalus.
C. The patient may benefit from a diversionary cerebrospinal fluid shunt.
D. The images confirm the presence of a cerebrospinal fluid leak.

**Findings:**
There is early reflux of radiotracer into the lateral ventricles, which persists over 48 hours. There is also significantly delayed migration of the radiotracer over the convexities.

**Rationale:**
A: This is a cisternogram and not a study assessing VP shunt patency. There is no VP shunt present.
B: The early and persistent ventricular activity in this case is consistent with free communication between the ventricles and the extraventricular CSF space. In non-communicating hydrocephalus, a normal pattern would be observed, without evidence of ventricular reflux.
C: Cisternography is sometimes performed in the pre-operative evaluation of patients with clinical and imaging findings of normal pressure hydrocephalus (a type of communicating hydrocephalus). Although somewhat controversial, cisternography demonstrating both early and persistent lateral ventricular activity and significantly delayed migration of the radiotracer over the cerebral convexities (Type IV pattern of CSF flow) suggests that the patient is more likely to benefit from CSF shunting than if these findings are not present.
D: This type of procedure can certainly be performed for suspected CSF leak. However, the images do not demonstrate a leak.
245. The lead NM technologist shows the radiologist the intrinsic QA uniformity image depicted below. Their conclusion is that:

A. service should be called to repair a failed PMT.
B. a new high-count SPECT uniformity correction image should be acquired.
C. the collimator has collision damage and should be replaced.
D. a COR correction should be acquired.

Rationales:
A: Correct.
B: This failure in the basic (planar) operation of the camera and is too severe to be corrected by a high count flood.
C: No collimator will be present in an intrinsic uniformity test and, even if this were an extrinsic test, the damage shown would be more extreme than is common with mechanical collimator damage.
D: A COR correction would be appropriate if certain types of SPECT artifacts were present.

246. Regarding hepatobiliary scintigraphy, which of the following findings is MOST associated with chronic cholecystitis?

A. Delayed blood pool clearance
B. Increased renal excretion
C. Prolonged biliary-to-bowel transit time
D. Rim sign

Rationale:
A: Delayed clearance of the radiopharmaceutical from the blood pool (>10 minutes clearance) is seen in the setting of hepatocellular dysfunction, and is not associated with chronic cholecystitis. Another finding of hepatocellular dysfunction is increased renal excretion, due to alternative clearance of activity by the kidneys.
B: Increased renal excretion of the radiopharmaceutical is seen in the setting of hepatocellular dysfunction, and is not associated with chronic cholecystitis. When increased renal excretion is present, there is generally also delayed clearance of radiopharmaceutical from the blood pool, further confirming the presence of poor hepatic function.
C: Prolonged biliary-to-bowel transit time is associated with chronic cholecystitis, with the diagnosis becoming more likely the greater the delay. This finding may be associated with prolonged retention of activity within the gallbladder, in turn secondary to impaired gallbladder motility related to chronic inflammation. In such cases, infusion of a cholecystokinin analog may demonstrate the presence of impaired gallbladder motility, confirming the diagnosis.
D: The rim sign is seen in the setting of acute cholecystitis. It is associated with a significant increased incidence of gangrenous or perforated gallbladder. Its mechanism is not clear, but is postulated to be due to reactive regional hyperemia in the liver due to adjacent gallbladder inflammation.
247. What is the optimal time for post-therapy whole-body I-131 scintigraphy following I-131 therapy for well-differentiated thyroid carcinoma?
   A. Immediately after administration of the therapeutic dose
   B. 24 hours post-therapy
   C. 5 to 7 days post-therapy
   D. 3 months post-therapy

**Rationale:**
A: Imaging on the day of the therapy would not optimally reflect the ultimate biodistribution of the I-131, not permitting adequate localization time for assessing thyroid tumor tissue uptake, and would also result in a higher radiation exposure to the Nuclear Medicine technologist performing the study.
B: Again, imaging at 24 hours would be too soon to optimally assess the distribution of the therapy dose, with significant blood pool and urinary activity still present.
C: This is probably the optimal timeframe for post-therapy imaging, after initial blood pool clearance has largely occurred, permitting adequate assessment of the biodistribution of the therapy dose, while at the same time providing the improved resolution afforded by the larger amount of radioactivity present in the patient.
D: By 3 months post-therapy, greater than 10 half-lives of the I-131 therapy dose have passed (T1/2 = 8 days), resulting in minimal residual activity and non-diagnostic images. Therefore, images obtained at this time would be of no clinical value.

248. According to Nuclear Regulatory Commission (NRC) regulations, what is the maximum total effective dose equivalent (TEDE) exposure allowed to other individuals to safely release a patient immediately following radioiodine therapy?
   A. 1 mSv (100 mrem)
   B. 3 mSv (300 mrem)
   C. 5 mSv (500 mrem)
   D. 7 mSv (700 mrem)

**Rationale:**
A: Incorrect.
B: Incorrect.
C: § 35.75 Release of individuals containing unsealed byproduct material or implants containing byproduct material. (a) A licensee may authorize the release from its control of any individual who has been administered unsealed byproduct material or implants containing byproduct material if the total effective dose equivalent to any other individual from exposure to the released individual is not likely to exceed 5 mSv (0.5 rem).
D: Incorrect.
249. A woman who is breast-feeding is scheduled for an F-18 FDG PET scan. How long should she quit
breast-feeding?
   A. No need to stop breast-feeding
   B. 2 hours
   C. 24 hours
   D. Complete cessation of breast-feeding

**Rationale:**
A. Incorrect.
B. Incorrect.
C. 24 hours. The half-life of F-13 is 120 minutes (2 hours) and therefore 24 hours is approximately 10 half-
life which indicates a safe time before breast feeding can be resumed.
D. Incorrect.

250. Which of the following is the MOST common cause of uptake in an axillary lymph node on a planar
Tc-99m MDP bone scan?
   A. Metastatic lymphadenopathy
   B. Melanoma
   C. Intra-arterial injection of the radiopharmaceutical
   D. **Extravasation at the injection site**

**Rationale:**
A: Metastatic lymphadenopathy is not a common cause of this finding.
B: Melanoma is not a common cause of focal axillary lymph node uptake on a bone scan.
   Lymphoscintigraphy in melanoma is performed by injecting filtered Tc-99m sulfur colloid
   intradermally surrounding the site of the primary cutaneous lesion or previous biopsy site.
C: Intra-arterial injection may result in diffusely increased soft tissue uptake within the involved extremity,
   distal to the injection site, in a stocking/glove distribution. It does not cause focal axillary lymph node
   uptake.
D: Extravasation at the injection site is a common cause of uptake in an axillary node, secondary to
   formation of small colloidal particles that are taken up by lymphatics and deposited in ipsilateral
   axillary nodes. This finding should not be mistaken for disease, and can be confirmed by imaging the
   injection site to identify the extravasation of the dose.
251. Regarding Ga-67 citrate and In-111 WBC scintigraphy in suspected spinal infections, which one of the following statements is CORRECT?

A. Ga-67 citrate imaging is superior for detection of discitis.
B. In-111 WBC imaging is superior for detection of chronic osteomyelitis.
C. Both are inferior to Tc-99m bone scintigraphy in detecting infections in patients with underlying postsurgical changes.
D. False-positive studies are less common with In-111 WBC imaging.

Rationale:
A: In-111 labeled WBCs have lower sensitivity for this entity.
B: Because of the low sensitivity of In-111 WBC scintigraphy for the detection of infection in the spine, especially in the case of chronic infection, gallium-67 citrate is considered to be the better agent for this indication.
C: Bone scans are frequently non-diagnostic or falsely positive in the evaluation for osteomyelitis superimposed on an underlying process, such as fracture or a painful orthopedic prosthesis, since increased tracer uptake may also result from increased bone turnover related to metabolic activity associated with these other conditions.
D: False positive studies with In-111 WBC imaging of the spine are common, and can occur up to 20% of the time.

252. For a whole-body PET/CT scan performed with 15 mCi of F-18 FDG and a CT scan done from the base of the brain to mid-thigh (100 mAs @ 120 kVp, pitch of 1), what is the approximate effective radiation dose considering both internal and external radiation sources?

A. 5 mSv (0.5 rem)
B. 10 mSv (1 rem)
C. 25 mSv (2.5 rem)
D. 50 mSv (5 rem)

Rationale:
A: This is too small.
B: This is just the PET dose.
C: The PET scan alone with 10-12 mCi of F-18 FDG delivers about 10 mSv. A CT of the chest and abdomen will deliver another 10-20 mSv, depending on technique.
D: This is too high.
Regarding ventilation-perfusion scintigraphy, which of the following findings is associated with the HIGHEST likelihood of acute pulmonary embolism?

A. Upper lobe triple match
B. Lower lobe triple match
C. Whole-lung V/Q match with a normal chest radiograph
D. Perfusion defect corresponding to a large pleural effusion

Rationale:
A: Although classically all triple matched findings (ie., corresponding ventilation, perfusion and radiographic abnormalities) are consistent with an intermediate probability for pulmonary embolism, according to the revised PIOPED criteria, a triple match in the upper lobes is much less likely to be due to pulmonary embolism than a lower lobe triple match. This finding is consistent with the fact that pulmonary emboli occur much more commonly in the lower lobes than the upper lobes, most likely as a result of the relatively greater blood flow to those areas.

B: A lower lobe triple match is more likely to be associated with pulmonary embolism than an upper lobe match, and according to the modified PIOPED criteria, is more worrisome than the finding of a triple match overall, which is generally considered to be consistent with an intermediate probability for pulmonary embolism.

C: A whole-lung V/Q match is most often associated with primary ventilatory disorders associated with secondary reflex vasoconstriction, such as airway obstruction due to central foreign bodies, mucus plugging, endobronchial masses or other unilateral primary ventilatory disorders, such as Swyer-James Syndrome. This finding is consistent with a low probability for acute pulmonary embolism.

D: While classically this finding is consistent with an intermediate probability for pulmonary embolism, in general, the larger the corresponding pleural effusion, the less likely it is due to pulmonary embolism.
254. Which of the following radionuclide imaging modalities is the MOST effective in preventing artifactual myocardial perfusion defects due to soft tissue attenuation?

A. Stress/rest Tc-99m sestamibi SPECT
B. Dual-isotope thallium-201 chloride/Tc-99m sestamibi SPECT
C. F-18 FDG (fluorodeoxyglucose) PET
D. Stress/rest rubidium-82 PET

Rationale:
A: Tc-99m sestamibi SPECT imaging is affected by soft tissue attenuation artifacts, such as breast and diaphragmatic attenuation, unless the data specifically undergoes some type of attenuation correction, either by means of software correction of hardware correction, such as the use of a hybrid SPECT-CT imaging device.
B: As in the case of Tc-99m sestamibi SPECT imaging, the dual-isotope method is also subject to soft tissue attenuation artifacts, unless specifically corrected. In fact, because of the lower gamma photon energies used in thallium-201 chloride myocardial perfusion imaging, the thallium images are even more prone to these artifacts than the images obtained using Tc-99m labeled radiopharmaceuticals.
C: There is attenuation correction in FDG PET images, whether performed on a dedicated PET imaging device which uses external radioactive sources for attenuation correction, or on a hybrid PET-CT imaging device. However, FDG myocardial scintigraphy is used to assess myocardial glucose metabolism, and is not a myocardial perfusion imaging study.
D: Rb-82 is a positron-emitting isotope with a short half-life of 75 seconds that is used for assessment of myocardial perfusion. It is a potassium analog, and exhibits biochemical properties similar to those of Ti-201 chloride. In addition, being a PET radiopharmaceutical, the use of Rb-82 for myocardial perfusion imaging benefits from the image attenuation correction that is intrinsic to all PET and PET-CT studies.

255. According to the World Health Organization (WHO) recommendations, which of the following bone densitometry findings is diagnostic for osteoporosis?

A. T score < 0
B. T score < -2.5
C. Z score < 0
D. Z score < -2.5

Findings:
WHO definition of osteoporosis is a bone mineral content measurement that is equal to or greater than 2.5 standard deviations below the expected measurement of a young normal control group (T score <-2.5).

Rationale:
A: The WHO defines osteoporosis as a T score < -2.5.
B: This is the WHO definition for osteoporosis, although this finding may also be seen in osteomalacia. In addition, many patients with T scores higher than -2.5 are deemed to be appropriate candidates for treatment of bone loss. The T score is derived by comparison with a young adult normal control group.
C: The Z score is derived from comparison with age, sex and race-matched controls, and is not a direct indicator of osteoporosis.
D: Again, the T score rather than the Z score is used to define the presence of osteoporosis. A highly negative Z score indicates bone loss out of proportion to the patient's age, sex and race.
256. Regarding radiochemical purity of Tc-99m-labeled radiopharmaceuticals, which of the following statements is CORRECT?

A. It is determined by the ratio of Mo-99 to Tc-99m in the generator eluate.
B. It is determined by the amount of alumina in the generator eluate.
C. **It is assessed using thin-layer chromatography.**
D. It is assessed using a colorimetric spot test.

**Rationale:**
A: The ratio of Mo-99 to Tc-99m is a measure of radionuclidic purity.
B: The presence of alumina in the eluate represents a type of chemical impurity, involving a non-radioactive contaminant within the radiopharmaceutical, and does not represent a radiochemical impurity.
C: Radiochemical purity is defined by the fraction of radioactivity in a dose that is in the desired chemical form, such as the amount of properly labeled Tc-99m MDP versus the remaining free Tc-99m pertechnetate within a bone scan dose. Thin-layer chromatography is the most common method of testing radiochemical purity with Tc-99m labeled compounds.
D: The amount of alumina in the eluate, which is a measure of chemical purity, is commonly measured using this technique.

257. Regarding radionuclide imaging in patients with intractable seizures, which of the following findings is MOST LIKELY to be observed during the interictal phase?

A. Focal area of increased perfusion on SPECT perfusion brain imaging
B. **Focal area of decreased perfusion on SPECT perfusion brain imaging**
C. Focal area of increased glucose metabolism on FDG PET imaging
D. Crossed cerebellar diaschisis on FDG PET imaging

**Rationale:**
A: The opposite is true.
B: Seizure foci, particularly in the temporal lobes, typically demonstrate decreased perfusion (SPECT) and decreased metabolic activity (PET) during the interictal phase and increased perfusion and metabolic activity during the ictal phase.
C: Metabolic activity is typically decreased during the interictal phase.
D: This finding can be seen in the setting of a supratentorial lesion, such as a stroke or tumor that results in decreased activity in the contralateral cerebellar hemisphere. It is not a typical finding in patients with isolated seizure disorders.