Nuclear Medicine Board Review

Questions and Answers for Self-Assessment

Fourth Edition

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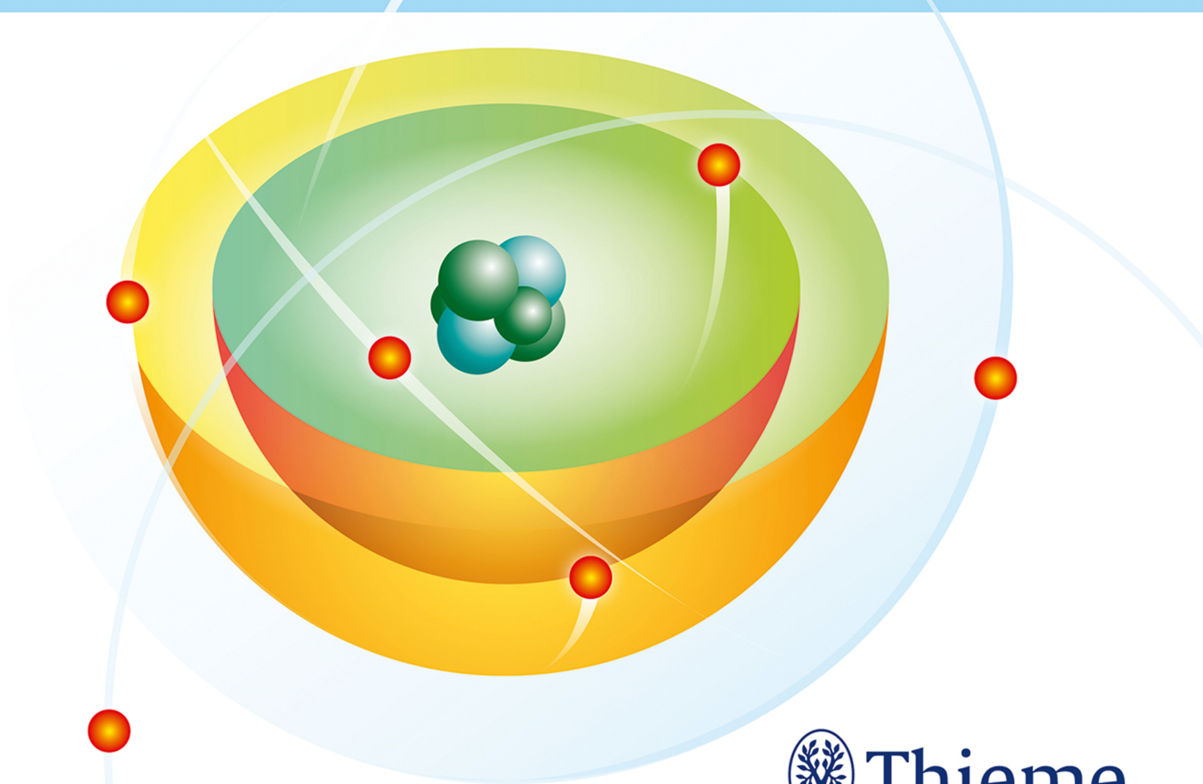

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To the kind L-rd for blessing me with empathetic and insightful life partners: Linda (home), Fukiat (work), Murthy (cyberspace), and with personal and professional friends who made this fourth edition happen!

– C. Richard Goldfarb

To my dearly loved parents Janaki and Lakshmipathi Chamarthy, my beloved wife Prasanna and joyous children Gautam and Divya, and also to my mentors, Dr. David M. Milstein and Dr. Leonard M. Freeman, for being a constant source of inspiration and enlightenment.

– Murthy R. Chamarthy

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– Fukiat Ongseng

To my father, Leon Parmett, with love and admiration, and to my wife, Ofra, and my children, Zecharya, Avraham, Yonatan, and Rachel, with love and appreciation.

– Steven R. Parmett

Dedicated to the life and memory of my father David L. Bushnell Sr.

– David L. Bushnell Jr.

To my family with love.

– Rosna Mirtcheva-Trocheva

To my parents, Nilabja and Jayasri Sen for all they have done and continue to do for me. I would not be the person I am today without you.

– Urmi Sen

To my family.

– Lionel S. Zuckier

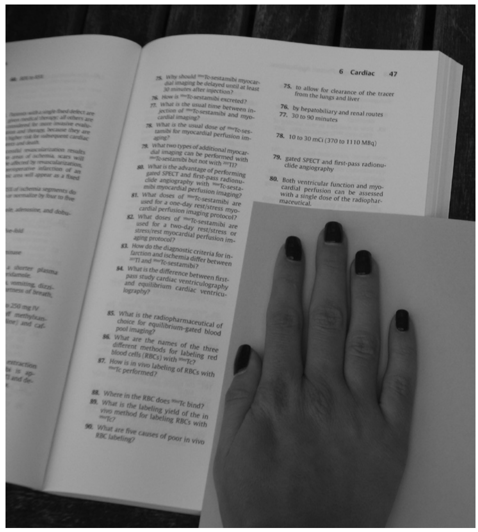
Contents

Preface

Nuclear medicine has made great strides since the first edition of this book was published in 1998, and it continues to evolve. PET/CT now dominates clinical practice, SPECT/CT is the standard of care, and hybrid MRI is in view. Radionuclide therapy is burgeoning. SIRT of hepatic tumors is routine at many centers, the first alpha emitter is now approved for treatment, and PSMA-targeted "theranostics" is hot at radiology, urology, and oncology meetings.

This fourth edition of *Nuclear Medicine Board Review: Questions and Answers for Self-Assessment* matches the growth of the field with the inclusion of high-yield images and updates across all sections, while carefully retaining the original flavor and the longstanding educational content. Additionally, the multiple-choice question format has been expanded to simulate a real-world exam. As you see, we retain the popular interactive question-and-answer format, designed to speed assimilation of relevant information and enhance retention. The appendices again include terse tips for test takers, instant essentials for image interpreters and "must know" concepts, along with cases and calculations at all levels. The 2,250 questions in twenty-four chapters, with the novel emphasis on image based and MCQ style, fortify the reader with current molecular imaging knowledge.

We hope and expect that this book will facilitate success across the 'boards', not only for certification (and re-cert) seekers, but for all who wish to embark upon a joyful journey and immerse themselves in an exciting specialty. As ever, we warmly welcome your comments and suggestions.



A piece of paper may be held over the answers column, then moved to reveal each answer as needed.

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Part I

Essentials of Nuclear Medicine

1 Radionuclides and Radiopharmaceuticals

Questions

1. Nuclides with the same atomic number (i.e., the same number of protons) but different numbers of neutrons (e.g., ^{15}O, ^{16}O, ^{18}O) are called ________.
2. Two nuclides with the same atomic mass but different atomic numbers are called ________.
3. Two nuclides with the same number of neutrons but different atomic numbers are called ________.
4. What is a radionuclide?
5. Another name for a helium ion containing two protons and two neutrons is ________.
6. What is a beta (β) particle?
7. Why are alpha (α) and beta (β) particles not used for imaging?
8. What ratio of protons to neutrons favors beta (β) decay?
9. What two particles are emitted from the nucleus during beta (β) decay?
10. What is the relationship between the mean energy and the maximum energy of a beta (β) spectrum?
11. What ratio of protons to neutrons favors positron decay?
12. What particles are released from the nucleus during positron decay?
13. What is the minimum amount of nuclear energy required for positron decay?
14. What is the fate of a positron?
15. When a positron is annihilated via combination with an electron, the result is the production of ________.
16. What ratio of protons to neutrons favors electron capture decay?

Answers

1. isotopes
2. isobars
3. isotones
4. A nuclide that emits particulate or photon energy to achieve a more stable energy state.
5. an alpha (α) particle
6. An electron.
7. They do not exit the body efficiently and thus are not detected.
8. A low proton-to-neutron ratio, as compared with stable nuclei.
9. A beta (β) particle (electron) and an antineutrino.
10. The mean energy is approximately one-third of the maximum energy.
11. A high proton-to-neutron ratio.
12. A positron (antielectron) and a neutrino.
13. 1.02 MeV.
14. To travel a short distance, combine with an electron, and be annihilated.
15. two nearly opposed 511-keV photons
16. A high proton-to-neutron ratio.

17. What particle is released from the nucleus during electron capture decay?

17. A neutrino.

18. What is released from the nucleus during isometric transition?

18. Gamma (γ) rays.

19. Other than wavelength, frequency, and energy intensity, the fundamental difference between X-rays and gamma (γ) rays is __________.

19. that X-rays are produced from energy released due to changes in the quantum levels/values of orbital electrons of an atom, while gamma (γ) rays are produced from energy shifts in the nucleus

20. When energy from a nuclear transition results in the emission of an orbital electron rather than a gamma (γ) ray, this process is called __________.

20. internal conversion

21. Internal conversion electrons increase the radiation dose to the patient because __________.

21. energy from the electron is absorbed within the patient's body

22. When energy from an orbital transition results in the emission of an orbital electron rather than an X-ray, the electron is called __________.

22. an Auger electron

23. What does the term "metastable" mean?

23. When an isomeric state is long-lived (i.e., longer than 10^{-12} s).

24. After an electron is ejected from an inner shell orbital, what occurs?

24. Outer shell electrons release energy by moving to now unoccupied, less energetic inner orbitals; the energy released by this transition is termed "characteristic of X-ray radiation."

25. What are the two methods used to create synthetically radioactive materials?

25. Radioactive materials are produced by bombarding a target material with either ions or with neutrons.

26. A __________ is used to bombard elements with neutrons.

26. nuclear reactor

27. An __________ is used to bombard elements with protons.

27. accelerator (linear or cyclotron)

28. Name the five common cyclotron-produced radionuclides used in nuclear medicine.

28. ^{111}In, ^{123}I, ^{67}Ga, ^{18}F, and ^{201}Tl.

29. What is a carrier-free radioisotope?

29. A radioisotope that does not contain any nonradioactive species.

30. What does the term "activity" mean?

30. The rate of disintegration of a radionuclide.

31. The unit of radioactivity equal to 3.7×10^{10} disintegrations per second is called __________.

31. the curie (Ci)

32. What is a becquerel (Bq)?

32. The derived unit of radioactivity used by modern metric system, the SI (*Système International d'unités*), is called the becquerel. One becquerel is equal to one disintegration per second, or 2.7027×10^{-11} Ci.

33. A 1-millicurie dose of a radiopharmaceutical is equal to how many becquerels?

34. What does the term "specific activity" mean?

35. The time it takes a radionuclide to decay to one-half of its original activity is called its __________ half-life.

36. What is the relationship between physical half-life and the decay constant?

37. The time required for a substance in the body to be reduced to half its concentration via biological excretion or metabolism is called its __________ half-life.

38. Which type of half-life refers to the overall loss of radioactivity from the body due to physical and biological decay?

39. What is the relationship between effective half-life, physical half-life, and biologic half-life?

40. A radiopharmaceutical with a 6-hour physical half-life and a 3-hour biologic half-life has an effective half-life of __________.

41. A common type of transient equilibrium is a __________ generator.

42. When a daughter radionuclide has a half-life longer than that of a parent, there is __________ equilibrium.

43. When a parent half-life is much longer than that of a daughter, there is __________ equilibrium.

44. What are the components of $^{99}Mo/^{99m}Tc$ generator systems?

45. What is the half-life of ^{99}Mo?

46. How is a $^{99}Mo/^{99m}Tc$ generator system eluted?

47. Maximum build-up of ^{99m}Tc in a $^{99}Mo/^{99m}Tc$ generator system occurs after __________ hours.

48. What does the term "breakthrough" mean when applied to a radionuclide generator system?

49. What are the major emissions of ^{99m}Tc?

50. By what method does ^{99m}Tc decay?

51. What is the half-life of ^{99m}Tc?

33. 37 million (37 MBq).

34. Specific activity refers to the ratio of activity per unit mass (e.g., mCi/mg, mCi/mole, MBq/mg or MBq/mole).

35. physical

36. Their product equals 0.693.

37. biological

38. The effective half-life.

39. 1/physical half-life + 1/biologic half-life = 1/effective half-life.

40. 2 hours

41. $^{99}Mo/^{99m}Tc$

42. no

43. secular

44. Alumina (Al_2O_3) column loaded with ^{99}Mo, an eluting solvent, an evacuated collecting vial, and shielding.

45. 2.8 days (66 hours).

46. ^{99m}Tc is removed by passing saline through the column.

47. 23

48. A "breakthrough" occurs when some parent nuclide (e.g., ^{99}Mo) elutes off the column along with a daughter nuclide (e.g., ^{99m}Tc).

49. 140 keV photons.

50. Isomeric transition.

51. Six hours.

52. What are the possible valence states of ^{99m}Tc?

53. What is the valence state and chemical form of ^{99m}Tc eluted from a generator?

54. $^{99m}TcO_4^{-1}$ must first be __________ to a valence state of +4 prior to incorporation into most chelates.

55. Reduction of technetium in commercial radiopharmaceutical kits is generally achieved with __________.

56. __________ is the single radiopharmaceutical in which technetium is not reduced from its +7 oxidation state.

57. Where does intravenously administered ^{99m}Tc pertechnetate concentrate?

58. For lung perfusion scanning with ^{99m}Tc-macroaggregated albumin (MAA), __________ particles are typically administered.

59. What is the half-life of ^{123}I?

60. What is the mode of decay of ^{123}I?

61. What is the energy of the photons emitted by decay of ^{123}I?

62. What is the half-life of ^{131}I?

63. What is the mode of decay of ^{131}I?

64. What is the predominant photon emitted by decay of ^{131}I?

65. What does gallium primarily bind to in plasma?

66. What biologically important element does gallium most closely mimic?

67. What is the half-life of ^{67}Ga?

68. What are the predominant photons emitted by the decay of ^{67}Ga?

69. How is gallium excreted?

70. What is the main excretory pathway for gallium in the first 24 hours?

71. What is the half-life of ^{111}In?

72. What are the predominant photons emitted by the decay of ^{111}In?

73. What are the two important uses of ^{111}In in nuclear medicine?

74. ^{111}In-labeled pentetreotide (Octreoscan) is an example of a class of imaging agents called __________.

52. Eight oxidation states from -1 to +7.

53. In pertechnetate (TcO_4^{-1}), Tc is in the +7oxidation state.

54. reduced

55. stannous (tin[II]) ion

56. ^{99m}Tc sulfur colloid

57. In the stomach, salivary glands, thyroid, small and large bowel, choroid plexus, lactating breasts, and kidneys.

58. 200,000 to 500,000

59. 13.2 hours.

60. Electron capture.

61. 159 keV.

62. 8.04 days.

63. Beta (β) emission

64. A 364-keV photon.

65. Transferrin.

66. Iron (same oxidation state and similar ionic radius).

67. 3.24 days (78 hours).

68. 93-, 185-, 300-, and 394-keV photons.

69. Through the kidneys and bowel.

70. Urine (10% of administered dose).

71. 2.83 days (68 hours).

72. 171- and 245-keV photons.

73. For the labeling of (1) leukocytes, (2) proteins (such as Octreoscan).

74. receptor-binding peptides

75. Pentetreotide binds to __________ on the surface of a tumor.

75. somatostatin receptors

76. Octreotide, the peptide that is labeled in Octreoscan, has a length of __________ amino acids.

76. eight

77. What is the half-life of ^{201}Tl?

77. 3.04 days (72.9 hours).

78. What are the predominant photons emitted by the decay of ^{201}Tl?

78. Mercury X-rays of 69 to 71 keV and 80 keV.

79. What is the mechanism of ^{201}Tl decay?

79. Electron capture.

80. What is the usual chemical form of ^{201}Tl?

80. Thallous chloride (TlCl).

81. What biologically important ion does ^{201}Tl most closely mimic?

81. Potassium (same charge and similar ionic radius).

82. How are positron-emitting radionuclides used for imaging?

82. They are used in PET imaging, where the coincident annihilation photons are simultaneously detected.

83. The main technical difficulty with positron emission tomography (PET) radionuclides is that they tend to have __________.

83. a very short half-life

84. Positron-emission radionuclides, which are used in PET scanning, tend to be produced by generator systems or by an on-site __________.

84. cyclotron

85. ^{18}F-fluoro-deoxyglucose (FDG) is an analog of __________, which is taken up by cells and phosphorylated but cannot be further processed.

85. glucose

86. The property of ^{18}F-FDG that makes it useful for imaging cancer is that __________.

86. malignant tissues derive energy preferentially using the anaerobic metabolism of glucose

87. ^{82}Rb, used for PET myocardial perfusion studies, is obtained from an __________ generator.

87. ^{82}Sr

88. The mechanism of localization in __________ is achieved by capillary blockade.

88. perfusion lung scanning

89. Bone scintigraphic agents localize by the process of __________.

89. adsorption onto hydroxyapatite (chemi-adsorption)

90. A radiopharmaceutical that localizes by phagocytosis is __________.

90. ^{99m}Tc–sulfur colloid

91. Antibody-imaging agents localize by __________.

91. antigen-antibody binding

92. Somatostatin analogs localize by __________.

92. receptor binding

93. ^{89}Sr chloride (Metastron) is a therapeutic radiopharmaceutical used to treat __________.

94. ^{89}Sr, a beta (β) emitter, decays with a physical half-life of __________.

95. The two photons produced in a positron/electron annihilation are oriented at an angle of approximately __________ to each other.

96. The positron-emitting radionuclides ^{11}C, ^{13}N, ^{15}O, and ^{18}F are all produced by a __________.

97. In PET, a method for creating attenuation correction that is more rapid and results in less noise than source-based transmission scanning is based on __________.

98. Annihilation usually occurs approximately several __________ from the site of emission of the positron.

99. The half-life of ^{18}F is __________.

93. the pain of bony metastases

94. 50.5 days (1212 hours)

95. 180 degrees

96. cyclotron

97. computed tomography (CT)

98. millimeters

99. 110 minutes

2 Instrumentation

Questions

1. What is a gamma camera crystal made of?
2. What is the purpose of the crystal in a gamma camera?
3. What is the mechanism by which gamma (γ) rays interact with a gamma camera crystal?
4. What is the relationship between the energy of an absorbed gamma (γ) ray and the amount of light produced by a gamma camera crystal?
5. What is the purpose of the photomultiplier tube (PMT) array?
6. How does increasing crystal thickness influence camera sensitivity and resolution?
7. What is the output of a single PMT?
8. The PMTs are __________ to the crystal by optical grease or a light pipe.
9. What is the output of the PMT array decoder circuit?
10. How does increasing the number of PMTs affect the resolution?
11. How many PMTs are in a modern gamma camera?
12. The electronic component in a gamma camera that is used to disregard unwanted photons is called __________.
13. Why do scattered photons from within the patient cause major imaging difficulties?
14. What is the "window" in a pulse height analyzer (PHA)?
15. What are the energy limits of a 20% window centered at 140 keV?
16. Why do some gamma cameras have multiple PHAs?

Answers

1. Sodium iodide activated with thallium.
2. To absorb gamma (γ) rays and convert them into visible-light photons.
3. Photoelectric effect or Compton scattering.
4. The amount of light produced is directly proportional to the amount of energy lost by the absorbed gamma (γ) ray.
5. To detect the photons produced in the crystal and produce a proportional pulse.
6. Thick crystals (i.e., thicker than 0.5 inch or 1 cm) have higher sensitivity but lower resolution.
7. A pulse (very small signal) that represents amplification of the light detected.
8. optically coupled
9. Spatial coordinates (x^+, x^-, y^+, y^-) of the scintillation event.
10. It improves the resolution.
11. 75 or 91 per head.
12. a pulse height analyzer
13. The scattered photons lead to incorrectly positioned radioactive events.
14. The range of acceptable energies around a photopeak.
15. 126 to 154 keV.
16. To acquire several peaks simultaneously (e.g., ^{67}Ga).

17. What are the advantages of a digital camera?

17. It has better energy and spatial resolution, as well as less dead time.

18. Digital gamma cameras use a __________ to apply prestored energy and position corrections to each scintillation event.

18. computer

19. What is a gamma camera collimator made of?

19. Lead or tungsten.

20. What is the purpose of a gamma camera collimator?

20. Project an image of the source distribution directly onto the crystal.

21. What does the term "collimator sensitivity" mean?

21. The ratio of gamma (γ) rays that pass through the collimator to those incident upon it.

22. When is it appropriate to use a pinhole collimator?

22. When imaging small organs that lie close to the skin (e.g., thyroid gland).

23. What are the principal disadvantages of a pinhole collimator?

23. Image distortion and poor sensitivity.

24. As a pinhole collimator is brought closer to the object being imaged, the apparent size of the object __________.

24. increases

25. As a pinhole collimator is brought closer to the object being imaged, the resolution __________.

25. improves

26. As a pinhole collimator is brought closer to the object being imaged, the count rate __________.

26. increases

27. What is the most common type of collimator-hole alignment in nuclear medicine?

27. Parallel hole.

28. As a parallel-hole collimator is brought closer to the object being imaged, the resolution __________.

28. improves

29. As a parallel-hole collimator is brought closer to the object being imaged, the apparent size of the object __________.

29. remains the same

30. As a parallel-hole collimator is brought closer to an object being imaged, the count rate __________.

30. remains the same

31. Walls within the collimator that separate adjacent holes are called __________.

31. collimator septa

32. What is the purpose of collimator septa?

32. To block gamma (γ) rays traveling obliquely toward the crystal.

33. What does the term "septal penetration" mean?

33. Gamma (γ) rays passing obliquely through the collimator septa, leading to mispositioned events.

34. The presence of a starburst-type appearance when imaging a hot object with a parallel-hole collimator is due to __________.

34. septal penetration

35. What defines the energy range of a collimator?

35. The composition, thickness, and length of the septa.

36. How does increasing the septal length affect collimator resolution and sensitivity?

36. It improves the resolution and lowers sensitivity.

37. How does increasing the septal thickness affect collimator energy?

37. It permits the use of higher-energy gamma (γ) emitters.

38. Currently, parallel-hole collimators are constructed with __________-shaped holes. Why are the holes shaped in this fashion?

38. hexagonal. Holes in this shape can be more closely packed, thereby covering a greater area of the detector face.

39. For best resolution, how should a parallel-hole collimator be positioned relative to the patient?

39. As closely as possible.

40. The measure of the ability of the camera to separate events of differing energies is called __________.

40. energy resolution

41. The measure of the ability of an imaging system to distinguish two adjacent point sources as distinct is called __________.

41. spatial resolution

42. What does the term “intrinsic resolution” mean?

42. The resolution due to all components of the gamma camera system except the collimator.

43. What is the difference between intrinsic and overall (or extrinsic) resolution?

43. Overall (extrinsic) resolution includes the effect of the collimator.

44. Typical intrinsic resolution for a modern-day gamma camera at full width at half maximum (FWHM) is __________.

44. 3 to 5 mm

45. How does intrinsic resolution vary with photon energy?

45. Intrinsic resolution decreases as energy drops below an optimal energy range.

46. The time it takes the electronics of a system to reset after an event is called __________.

46. dead time

47. In what type of study is dead time most important?

47. High-count-rate studies (e.g., cardiac first pass).

48. The typical dead time for a modern gamma camera is __________.

48. 1 to 2 µs

49. The basic principle of single-photon emission computed tomography (SPECT) is__________.

49. by imaging in multiple planes around a subject, the system can reconstruct the original count distribution by using the mathematical algorithm of filtered back-projection or iterative reconstruction.

50. How is a conventional planar gamma camera modified to accomplish SPECT?

50. The camera head is made to rotate around the patient and is interfaced to a computer that reconstructs the data in three dimensions.

51.	When the camera rotates several degrees, acquires images in a stationary position, and repeats, the acquisition method is called ________.	**51.**	step and shoot
52.	The purpose of noncircular or elliptical orbits in SPECT imaging is ________.	**52.**	to improve spatial resolution by decreasing patient–collimator distance
53.	The advantages of multiple heads in a SPECT system are an increase in ________ and a decrease in ________.	**53.**	count-rate sensitivity; imaging time
54.	The major disadvantage of multiple heads in a SPECT system is difficulty in ________.	**54.**	the alignment and registration of the multiple heads
55.	What factor limits the total acquisition time of a SPECT study?	**55.**	Patient movement, especially due to fatigue.
56.	What is the advantage of iterative reconstruction over filtered back-projection?	**56.**	Less noise and streak artifacts, and can incorporate various corrections into the reconstruction process to create a more accurate result.
57.	What technical advance has permitted images to be reconstructed with iterative reconstruction rather than filtered back-projection?	**57.**	Availability of more powerful computers in the clinic.
58.	What is an image filter?	**58.**	A mathematical technique used to prevent unwanted components in the projection profiles from appearing in the reconstructed image.
59.	What filter is used specifically in filtered back-projection?	**59.**	A modified ramp filter—e.g., Hanning, Shepp–Logan, Butterworth.
60.	When can filtering be performed in SPECT processing?	**60.**	Either pre-reconstruction (two-dimensional) or post-reconstruction (three-dimensional).
61.	What is the binary number system?	**61.**	A base 2 numbering system, composed of zeros and ones and built upon powers of 2.
62.	Why do computers use the binary number system?	**62.**	Computers use the binary number system because they are based on circuits made from semiconductor materials, in which numbers (and all other information) can be stored only as a series of on and off signals represented by ones and zeros.
63.	How is the binary number 10011 written in the decimal system?	**63.**	$(1 \times 16) + (0 \times 8) + (0 \times 4) + (1 \times 2) + (1 \times 1) = 19$.
64.	What is a computer program?	**64.**	A series of lines of computer code that causes the computer hardware to perform a specific task.
65.	The part of a computer's memory that contains instructions that can be read but not changed by the user is called ________.	**65.**	read-only memory (ROM)
66.	The part of a computer's memory that provides temporary storage for program instructions and data is called ________.	**66.**	random-access memory (RAM)

3 Quality Control

Questions

1. The percentage of radioactivity in a preparation originating from the desired radionuclide is called __________ purity.
2. The maximum permissible amount of ^{99}Mo per mCi (per 37 MBq) of ^{99m}Tc is __________.
3. The radionuclidic purity of ^{99m}Tc __________ during the day because of the longer physical half-life of ^{99}Mo compared with ^{99m}Tc.
4. An important cause of impurity in ^{123}I preparations is __________.
5. A multichannel analyzer may be used to assess radionuclidic purity by evaluating the __________ of the sample.
6. The energies of ^{99}Mo photons are __________ and __________.
7. A simple, common method used to evaluate for the presence of ^{99}Mo in ^{99m}Tc samples uses a dose calibrator and __________.
8. The percentage of total radioactivity present in a preparation in the desired chemical form is called the __________ purity.
9. The presence of free $^{99m}TcO_4^{-1}$ (pertechnetate) in a ^{99m}Tc–red blood cell (RBC) preparation is an example of a __________ impurity.
10. In $^{99m}TcO_4^{-1}$ preparations, the three general forms of technetium are free pertechnetate, chelated technetium, and __________.
11. Reduced hydrolyzed technetium has a tendency to be taken up by which organ of the body?
12. The form of technetium that is concentrated by the thyroid and gastric mucosa is __________.

Answers

1. radionuclidic
2. 0.15 µCi per mCi (0.15 kBq per MBq)
3. decreases
4. ^{124}I
5. energy spectrum
6. 740 keV; 780 keV
7. a lead shield (pig) to differentially absorb the low-energy photons, while allowing the energetic ^{99}Mo photons to pass
8. radiochemical
9. radiochemical
10. reduced hydrolyzed technetium
11. The liver.
12. $^{99m}TcO_4^{-1}$ (pertechnetate)

13. If it is suspected that gastric activity on a bleeding scan is a result of free pertechnetate, then one should image the __________ to confirm.	**13.** thyroid
14. The most common means of evaluating radiochemical purity is by use of __________.	**14.** instant thin layer chromatography
15. As a general rule of thumb for radiopharmaceuticals made with $^{99m}TcO_4^{-1}$, the radiochemical purity should be __________.	**15.** at least 90%
16. __________ impurity refers to the presence of nonradioactive compounds in a preparation that may interfere with the normal behavior or safety of the radiopharmaceutical.	**16.** Chemical
17. A common source of chemical impurity that originates from the $^{99}Mo/^{99m}TcO_4^{-1}$ generator is __________.	**17.** aluminum from the alumina column
18. The presence of excess amounts of aluminum in a ^{99m}Tc–sulfur colloid preparation leads to excess uptake in this organ of the body.	**18.** The lungs.
19. The presence of excess amounts of aluminum in a ^{99m}Tc–methylene diphosphonate (MDP) preparation leads to excess uptake in this organ of the body.	**19.** The liver.
20. The presence of aluminum in a generator eluate can be tested by__________.	**20.** indicator paper (aurintricarboxylic acid)
21. The permissible quantities of aluminum in a fission ^{99}Mo generator eluate are __________.	**21.** less than 10 μ/mL eluate
22. The presence of excess amounts of stannous ion in a ^{99m}Tc–MDP preparation leads to excess uptake in this organ of the body.	**22.** The liver.
23. Macroaggregated albumin should be of what particle size?	**23.** 90% between 10 and 90 μm diameter.
24. Sulfur colloid should be of what particle size?	**24.** 0.1 to 1 μm.
25. Fever-producing toxins that often originate in gram-negative bacteria and may contaminate radiopharmaceuticals are called __________.	**25.** pyrogens
26. The rapid method of testing for pyrogens is __________.	**26.** the limulus amebocyte lysate (LAL) assay (which uses the blood of the horseshoe crab, *Limulus polyphemus*)
27. The formal method of testing for pyrogens is by __________.	**27.** injecting the sample into rabbits and monitoring their temperature

28. Is endotoxin much more or much less toxic when radiopharmaceuticals are administered into the cerebrospinal fluid (CSF) compared to systematically administered preparations?

29. The absence of viable microbes within a radiopharmaceutical is called __________.

30. When there are increased counts at the periphery of the scintillation crystal due to internal reflection of light at the edges, the phenomenon is called __________.

31. Uniformity flood images of each gamma camera should be performed on a __________ basis.

32. In a gamma camera, the difference between an intrinsic flood and an extrinsic flood is that the intrinsic flood is __________.

33. The advantages of using a cobalt source rather than a liquid-filled phantom for performing floods are __________.

34. When intrinsic floods are performed using a point source, the point source should be located at least __________ away from the crystal to ensure a homogeneous distribution of radiation across the crystal face.

35. When the aluminum cover around a scintillation crystal is breached, the flood images can appear spotty because of __________ of the crystal.

36. The effect of a nonfunctioning photomultiplier tube (PMT) on a flood field is __________.

37. The term for tuning an energy window to the spectrum of a given isotope is __________.

38. The width of the measured spectrum for a particular gamma (γ) peak is a measure of the __________ of the gamma camera.

39. Peaking of the camera should be performed on a __________ basis.

40. The ability of a gamma camera to resolve objects that are close together is called the __________.

41. Spatial resolution should be tested on a __________ basis.

28. Much more.

29. sterility

30. edge packing

31. daily

32. performed without the collimator

33. more constant thickness and no air bubbles

34. five crystal diameters

35. hygroscopic degeneration

36. the presence of a discrete cold region

37. peaking

38. energy resolution

39. daily

40. spatial resolution

41. weekly

42. Spatial resolution is generally tested by imaging __________.

42. bar phantoms

43. The ability of the gamma camera to portray straight lines as straight is called __________.

43. spatial linearity

44. Spatial linearity should be tested on a __________ basis.

44. weekly

45. Difficulty in scaling the size of images taken at multiple energy peaks (e.g., with ^{67}Ga) is due to problems in __________.

45. z-pulse normalization

46. Why should quality assurance of a single-photon emission computed tomography (SPECT) gamma camera be stricter than that of a planar gamma camera?

46. A 1% nonuniformity in planar images has been shown to amplify to a 20% nonuniformity in the reconstructed SPECT images.

47. A __________ reconstruction artifact occurs with a nonuniform SPECT camera.

47. bull's-eye

48. How many counts should be obtained for a SPECT gamma camera uniformity flood?

48. A 64 × 64 matrix should have 30 million counts, while a 128 × 128 matrix should have 120 million counts.

49. For a SPECT camera, an additional quality control measure is verifying the __________.

49. center of rotation

50. How are center of rotation data used in a SPECT gamma camera?

50. For reconstructing three-dimensional images.

51. How accurate must the center of rotation be?

51. Optimally, within half a pixel.

52. How can the overall system performance of a SPECT camera be evaluated?

52. Acquire images of a SPECT phantom, e.g., a Jaszczak phantom.

53. What should the minimal intrinsic resolution, linearity, and uniformity of a SPECT gamma camera be?

53. Intrinsic resolution of 3 to 4 mm full width at half maximum (FWHM), spatial linearity of 0.2 to 0.6 mm, and intrinsic uniformity of 2 to 3%.

54. Before administration, every radiopharmaceutical must be assayed in a __________.

54. dose calibrator

55. A dose calibrator operates on the principle of an __________ chamber.

55. ionization

56. The linearity of a dose calibrator refers to the __________.

56. accuracy of measurement over the range of activities assayed, i.e., 10 mCi to1,000 Ci (370 kBq to 3.7×10^{13} Bq)

57. The linearity of a dose calibrator should be tested on a __________ basis.

57. quarterly

58. The simplest way to test the linearity of the dose calibrator is__________.

58. by counting a large dose of ^{99m}Tc over a period of multiple half-lives

59. A rapid method of testing linearity of the dose calibrator is __________.

59. by counting a large sample of ^{99m}Tc with and without attenuation by calibrated lead sleeves

60. The geometry of a dose calibrator refers to the relationship between __________.

61. The geometry of a dose calibrator should be tested __________.

62. Constancy (or precision) of measurement in a dose calibrator refers to the __________.

63. Dose calibrator constancy is evaluated by __________.

64. Constancy should be tested on a __________ basis.

65. According to Nuclear Regulatory Commission (NRC) regulations, constancy should be at least __________.

66. __________ refers to agreement with calibrated values when standards traceable to the National Bureau of Standards are measured.

67. Accuracy testing must be performed on a __________ basis.

68. Accuracy testing is performed by __________.

69. According to NRC regulations, accuracy of at least __________ is required.

70. When the dose calibrator is compared with the sodium iodide well counter, which of the two has the ability to differentiate the energies of different isotopes?

71. When two isotopes, such as ^{57}Co and ^{58}Co, are simultaneously counted in a well counter, the term "spilldown" refers to__________.

72. When two separate radionuclide imaging procedures are performed on the same patient on the same day, should the study using the higher-energy isotope generally be performed first or second?

73. Because of statistical variation in radioactive emissions, the standard deviation of a count of 900 is __________.

74. The term "radiation-absorbed dose" refers to __________.

60. measured activity and the position and shape of the source within the counting chamber

61. at installation and also after any major repair work

62. reproducibility of measurement over long periods of time

63. comparing interval measurements of a known standard source, e.g., ^{137}Cs, both at its own settings and at settings of other frequently used isotopes

64. daily

65. within 90%

66. Accuracy

67. daily

68. comparing measurements with expected values for at least two different radionuclide standards, such as ^{137}Cs and ^{57}Co, which are traceable to the National Bureau of Standards

69. 90%

70. Well counter.

71. the contribution of counts from the higher-energy isotope into the lower-energy window

72. Second.

73. 30, the square root of *n*

74. the amount of energy deposited per unit mass of absorbing tissue

75. The unit of measurement for the absorbed radiation dose is __________.

76. The term "dose equivalent," which is measured by this unit, refers to the radiation-absorbed dose multiplied by a quality factor that compensates for the particular type of radiation involved.

77. The unit of exposure referring to the level of ionization in the air is __________.

78. What is the purpose of a dose calibrator?

79. Why can a well counter not substitute for a dose calibrator?

80. Why must a dose calibrator be calibrated for each radionuclide to be measured?

81. The acronym ALARA refers to __________.

82. The occupational dose limit for a radiation worker in the United States is __________.

83. The occupational dose limit for a pregnant radiation worker in the United States is __________.

84. The dose limit for non–radiation workers in the United States is __________.

75. the rad (in the Système International [SI] or metric system, the gray, abbreviated Gy)

76. The rem (in the SI or metric system, the sievert, abbreviated Sv).

77. the roentgen (in the SI or metric system, coulombs/kilogram, abbreviated C/kg)

78. To measure or verify the activity of all patient doses, generator eluates, or any other large amount (mCi) of radioactive materials by conversion of the ionization current to a display of the radionuclide activity (Bq, Ci).

79. Because of the high detection efficiency of a well counter, dead-time problems exist for levels of activity greater than 1 µCi (0.037 MBq).

80. A dose calibrator has no energy discriminator components; it functions by measurement of the ionization current. This current is then converted to a measure of the activity by use of a predetermined calibration factor specific to each isotope.

81. the philosophy of reducing exposure from radionuclides to levels "as low as is reasonably achievable"

82. 5 rems per year (50 mSv per year)

83. 0.5 rem (5 mSv) for the declared gestational period

84. 0.1 rem per year (1 mSv per year)

4 Radiation Safety and Legal Requirements

Questions

1. True or false: In the United States, the Nuclear Regulatory Commission (NRC) regulates reactor-produced by-products, whereas the individual states regulate cyclotron-produced radioactive materials, including ^{18}F-FDG.
2. Which title within the Code of Federal Regulations (CFR) includes regulations related to nuclear medicine?
3. Define the term “absorbed radiation dose” and describe the units.
4. Define the term “equivalent radiation dose” and describe the units.
5. Define the term “effective dose.”
6. True or false: Stochastic effects (such as cancer or other genetic effects) are no-threshold effects, whereas nonstochastic effects are deterministic effects that have a threshold.
7. What are the annual occupational limits for radiation exposure?
8. What are the annual limits for radiation exposure for the general public?
9. What are the limits for radiation exposure during pregnancy?
10. True or false: The NRC calculates the dose limits by using a linear-dose, no-threshold model.

Answers

1. True.
2. Parts 19, 20, 30, and 35 of title 10 of the CFR contain the regulations concerned with nuclear medicine.
3. The absorbed radiation dose is the amount of energy absorbed per unit mass. One gray (Gy, which is an SI unit) is equal to 1 joule per kilogram. One Gy is equal to 100 rad.
4. The equivalent radiation dose is the radiation-absorbed dose multiplied by a radiation weighting/quality factor. 1 Sv (SI unit) = 100 rem.
5. The effective dose is the sum of the weighted equivalent doses in all of the organs and tissues of the body.
6. True.
7. The limits are 5 rem (50 mSv) total effective dose equivalent; 15 rem (150 mSv) to the eye lens; 50 rem (500 mSv) to any internal organ or extremity. The limits for minors are 10% of those for adult workers.
8. 0.1 rem (1 mSv).
9. 0.5 rem (5 mSv) after a declared pregnancy, uniformly distributed over the remaining months of the pregnancy.
10. True.

11. Which of the following are radiation monitoring devices?

a) Optically stimulated luminescence badge.
b) Thermoluminescent display.
c) Pocket ion chamber.
d) Electronic dosimeter.
e) All of the above.

12. The release rule is:

a) Activity based: less than 30 mCi or 1,110 MBq.
b) Dose rate based: less than 5 mrem or 0.05 mSv/h at 1 meter.
c) Dose limit based: less than 0.5 rem or 5 mSv public exposure.
d) 33 mCi or 1,221 MBq of ^{131}I/ 7 mrem or 0.07 mSv/h at 1 meter; additional occupancy factors can be included.
e) None of the above.

13. By-products with a physical half-life of less than 120 days are stored for __________ physical half-lives prior to disposal.

14. Define a medical event.

15. Define the types of radioactive package labeling.

16. Match each of the following to the criteria for either a major or a minor spill:

a) 2 mCi (74 MBq) of ^{131}I.
b) 25 mCi (925 MBq) of ^{99m}Tc.
c) 30 mCi (1,110 MBq) of ^{201}Tl.
d) 20 mCi (740 MBq) of ^{111}In.
e) 30 mCi (1,110 MBq) of ^{67}Ga.

11. e, all of the above.

12. c and d

13. 10

14. A medical event is required to meet two criteria and does not necessarily result in harm to the patient. A wrong radiotracer, wrong dose (differing by 20%), wrong route, or wrong site should result in exceeding annual occupational dose limits (a whole-body dose that exceeds 5 rem/50 mSv, or a 50 rem/500 mSv dose to organs and extremities).

15. Radioactive-white I materials do not require special handling and have a surface dose rate of less than 0.5 mrem (5 μSv)/h. For radioactive-yellow II, the surface dose rate is less than 50 mrem (0.5 mSv)/h, and the dose rate at 3 feet is less than 1 mrem (10 μSv)/h. For radioactive-yellow III, the surface dose rate is less than 200 mrem (2 mSv)/h, and the dose rate at 3 feet is less than 10 mrem (0.1mSv)/h.

16. a, major spill; b, minor spill; c, minor spill; d, major spill; e, major spill.

17. What are the guidelines for withholding or cessation of breast feeding after radionuclide studies?

18. Under what circumstances are written directives issued?

19. A written directive signed and dated by the authorized user includes which of the following pieces of information?

a) The patient's name.
b) The name of the radionuclide.
c) The dosage.
d) The route of administration.
e) All of the above.

17. Breast-feeding cessation is mandated for ^{131}I and recommended for ^{67}Ga. Breast feeding should be withheld 2 to 3 days for ^{123}I and 12 to 24 hours for most ^{99m}Tc-based tracers.

18. Written directives are issued by the authorized user for an ^{131}I dose of more than 30 μCi/1.11 Mbq or a therapeutic dosage of an unsealed by-product other than ^{131}I.

19. e, all of the above.

Part II

Single-Photon Applications

II

5 Musculoskeletal

Questions

1. What are the two main advantages of bone scintigraphy?
2. What is the main disadvantage of bone scintigraphy?
3. Which two factors give skeletal scintigraphy its specificity?
4. What class of radiopharmaceutical compound is most commonly used for skeletal scintigraphy?
5. Why are ^{99m}Tc-diphosphonates superior to ^{99m}Tc-pyrophosphates for skeletal scintigraphy?
6. How are ^{99m}Tc-diphosphonates prepared?
7. What percentage of the dose is in the blood at 2 to 3 hours after injection?
8. Why does ^{99m}Tc-diphosphonate have an affinity for newly formed bone?
9. What two factors affect the degree of ^{99m}Tc-diphosphonate in bone?
10. What is the body's critical organ for radiation dose in skeletal scintigraphy?
11. How can a patient decrease the radiation dose from a bone scan?
12. How should a patient be prepared for a bone scan?
13. What is the usual adult dosage and ^{99m}Tc route of administration of diphosphonates?
14. What special type of imaging should be performed with a bone scan for distinguishing suspected osteomyelitis from cellulitis?

Answers

1. High sensitivity for cortical lesions, and ease of surveying the entire skeleton.
2. The findings are often nonspecific.
3. The clinical context and the total body pattern.
4. ^{99m}Tc-diphosphonates.
5. ^{99m}Tc-diphosphonates have faster clearance.
6. Sodium pertechnetate ($NaTcO_4^-$) from a ^{99}Mo-generator is added to a vial with diphosphonate and stannous ion, Sn(II). The stannous ion reduces Tc, and the reduced Tc chelates to diphosphonate.
7. 3 to 5%.
8. It has higher absorption to amorphous $CaPO_4$ than to mature hydroxyapatite.
9. Bone formation and blood flow.
10. The bladder.
11. The patient should void frequently.
12. The patient should be well hydrated, should remove all metal objects (jewelry, coins, keys, etc.) before imaging, and should void immediately before the study and frequently after the procedure.
13. 20 mCi (740 MBq) intravenously.
14. Dynamic blood flow and immediate images.

15. When is delayed imaging performed for bone scanning?

15. At 2 to 4 hours after tracer injection.

16. How many counts are typically obtained for spot bone scan images?

16. 600,000 counts of anterior chest for spot views and all other views for the same time.

17. What types of collimators are used for bone scanning?

17. An all-purpose collimator is used for routine imaging; high-resolution, pinhole, or converging collimators are used for more detail.

18. How do bone scans of children and adolescents differ from bone scans of adults?

18. Epiphyseal uptake is present in bone scans of children and adolescents.

19. How do neonatal bone scans differ from bone scans of children and adolescents?

19. There is diffusely decreased uptake in neonatal bone scans.

20. What are four normal variants seen in the skull?

20. Uneven or variable, hyperostosis frontalis interna, sphenoid uptake, and uptake between orbits.

21. Why can joints show mild diffuse asymmetry?

21. Because of handedness (right or left).

22. Which joints can normally show increased uptake?

22. Sternomanubrial joint, sternal ossification centers, sacroiliac joints.

23. What is the mechanism of increased bone scan uptake by a bone metastasis?

23. The growth of the tumor causes surrounding bony remodeling.

24. How much change in bone density is required to see a skeletal metastasis on plain radiography?

24. 30 to 50%.

25. When can metastatic disease not cause the bone scan to be abnormal?

25. Marrow-based lesion.

26. Which imaging tests would be useful for marrow-based or lytic lesions?

26. MRI, ^{18}F-FDG.

27. What is the typical scintigraphic pattern of metastatic disease?

27. Multiple focal lesions distributed randomly in the axial skeleton.

28. Why can metastatic disease show a ring lesion on skeletal scintigraphy?

28. Uptake is in the reactive bone surrounding a large tumor; the tumor itself does not take up tracer.

29. How can the bone scan findings of osteomalacia and Cushing's syndrome be distinguished from metastatic disease?

29. There is a predominance of rib lesions in osteomalacia and Cushing's syndrome.

30. How can osteoarthritis be distinguished from skeletal metastases on a bone scan?

30. Osteoarthritis causes uptake that is limited to joints, commonly involving both sides of a joint.

31. How can trauma to the ribs be distinguished from skeletal metastases on a bone scan?

31. The lesions are aligned.

32. How can Paget's disease be distinguished from skeletal metastases on a bone scan?

32. In Paget's disease, uptake is characteristically intense and expansile, and it tracks along the length of a bone or hemipelvis.

33. What are four clues to the diagnosis of a superscan?

33. Increased bone-to-soft-tissue uptake, absent or faint kidney uptake, increased axial-to-appendicular uptake ratio, and ancillary findings on plain radiographs.

34. What is a “flare phenomenon”?	**34.** Increased uptake following chemotherapy due to healing of bone after regression of metastases.
35. Which five tumors commonly metastasize to bone?	**35.** Tumors of the prostate, breast, lung, kidney, and thyroid.
36. What is the mechanism of cold lesions on a bone scan?	**36.** Loss of blood flow or complete destruction of bone.
37. What tumors tend to cause no bone reaction on a bone scan?	**37.** Multiple myeloma.
38. What is the usual cause of positive lesions on a bone scan in a patient with multiple myeloma?	**38.** Pathologic fractures.
39. What is the sensitivity of an increased alkaline phosphatase scan for skeletal metastases from prostate cancer?	**39.** 50%.
40. What is the sensitivity of plain radiographs for skeletal metastases from prostate cancer?	**40.** 70%.
41. What percentage of stage I prostate cancer patients have skeletal metastases on a bone scan?	**41.** 5%.
42. What percentage of stage I breast cancer patients have skeletal metastases on a bone scan?	**42.** 3 to 5%.
43. How does mastectomy affect the bone scan?	**43.** Asymmetry of rib uptake.
44. What is the significance of sternal bone scan uptake ipsilateral to a primary breast cancer?	**44.** It indicates local invasion from metastases to inframammary nodes.
45. How does the typical distribution of metastatic disease from lung cancer differ from metastatic disease from breast or prostate cancer?	**45.** Appendicular involvement is more common.
46. What nonmetastatic finding is commonly seen on the bone scans of patients with lung cancer?	**46.** Hypertrophic pulmonary osteoarthro–pathy.
47. What is the typical location of skeletal metastases of neuroblastomas?	**47.** Metaphysis adjacent to the epiphyseal growth plate.
48. What percentage of primary neuroblastomas takes up the tracer on bone scanning?	**48.** 30 to 50%.
49. What are the usual age groups affected by osteoid osteoma?	**49.** Adolescents and young adults.
50. What is the typical uptake of most benign tumors of bone?	**50.** Mildly increased uptake.
51. What types of benign bone tumors can have increased uptake?	**51.** Osteoblastomas and osteoid osteomas.
52. When do enchondromas have markedly increased uptake?	**52.** When they are complicated by fracture.

53. What percentage of fractures are visualized on a bone scan by 24 hours?

53. 80%.

54. What percentage of fractures in patients under age 65 are visualized on a bone scan by 72 hours?

54. 95%.

55. When is fracture sensitivity maximal on bone scans in patients over age 65?

55. At more than 7 days.

56. What percentage of nondisplaced uncomplicated fractures is normal at 1 year?

56. 60 to 80%.

57. What percentage of nondisplaced uncomplicated fractures is normal at 3 years?

57. 95%.

58. How long does it take for complicated or displaced fractures to return to normal on a bone scan?

58. May remain positive indefinitely.

59. How does a craniotomy site present on a bone scan?

59. Ring pattern that persists for months.

60. How does rib resection during a thoracotomy affect a bone scan?

60. It causes rib uptake from periosteal reaction.

61. What do intercalary bone grafts look like on a bone scan?

61. Uptake at bone ends that gradually fill in as the graft revitalizes.

62. What do pedicle bone grafts look like on a bone scan?

62. Diffuse immediate uptake.

63. How does radiotherapy affect bone scan uptake at the site of radiation?

63. It initially causes mildly increased uptake, with persistently decreased uptake within 6 to 12 months in the geographic pattern of a radiation port.

64. What is the typical appearance of stress fractures?

64. Oval or fusiform uptake that is parallel to the long axis of the bone.

65. What is the prognostic difference between stress fractures and shin splints?

65. Stress fractures are predictive of further injury without relief of stress, while shin splints are not predictive of further injury.

66. What is the appearance of rhabdomyolysis on a bone scan?

66. Localization of tracer in damaged skeletal muscle corresponding to the muscle group that was overexercised.

67. When is the maximum bone scan uptake with rhabdomyolysis?

67. 1 week.

68. What is the appearance of newly infarcted bone on a bone scan?

68. A cold lesion.

69. What imaging technique should be used to detect the osteonecrosis of Legg–Calvé–Perthes disease on a bone scan?

69. Pinhole collimation.

70. What is the typical finding of Legg–Calvé–Perthes disease on a bone scan done early in the course of the disease?

70. A lentiform photon-deficient area in the upper outer femoral head.

71. What is the typical finding of Legg–Calvé–Perthes disease on a bone scan done in the middle of the course of the disease?

71. Uptake at the margin of a photon-deficient area in the upper outer femoral head.

72. What is the typical finding of Legg–Calvé–Perthes disease on a bone scan done late in the course of the disease?

72. Increased uptake in the femoral head.

73. What is the typical finding of steroid-induced osteonecrosis on a bone scan?

73. Increased uptake in the femoral head.

74. What are five findings of sickle cell disease on a bone scan?

74. Diffusely increased uptake in calvarium, more appendicular uptake than normal, increased skeleton-to-background uptake, kidneys larger than normal, and splenic uptake due to prior infarction.

75. What variation of a routine bone scan should be performed for the differentiation of osteomyelitis from cellulitis?

75. Three-phase scan.

76. How does one acquire the images for the first phase of a three-phase bone scan?

76. Inject the tracer as a bolus and obtain dynamic 2-second images for 60 seconds.

77. How does one acquire the images for the second phase of a three-phase bone scan?

77. Obtain 600,000 static images of the area immediately after the first phase.

78. What is the third phase of a three-phase bone scan?

78. Routine delayed images.

79. How do osteomyelitis and cellulitis differ on the first (flow) phase of a three-phase bone scan?

79. Osteomyelitis shows arterial hyperemia; cellulitis shows venous hyperemia.

80. How do osteomyelitis and cellulitis differ on the third (skeletal) phase of a three-phase bone scan?

80. Osteomyelitis shows focal skeletal uptake; cellulitis shows mildly diffused nonfocal uptake.

81. What is the typical appearance of a loose hip joint prosthesis on a bone scan?

81. Increased uptake at the greater and lesser trochanter, with increased uptake at the prosthesis tip.

82. What is the best scintigraphic method to distinguish between prosthesis loosening and infection?

82. White blood cell scan.

83. Which two metabolic bone diseases can show stomach and lung uptake on a bone scan, and why?

83. Primary hyperparathyroidism and renal osteodystrophy; hypercalcemia with calcium deposition in low-pH regions.

84. What is the role of the bone scan in patients with osteoporosis?

84. To detect and date insufficiency fractures.

85. How is the bone scan useful in the evaluation of myositis ossificans (MO)?

85. The degree of uptake diminishes with maturity of the site of calcification; mature lesions can be resected surgically.

86. Which of the following apply to osteoid osteomas?

a) They are approximately four times more common in males than in females.
b) They occur predominantly between the ages of 10 and 30.
c) The most common locations are the femur and tibia.
d) All of the above.
e) None of the above.

86. d, all of the above.

87. In osteoid osteomas, the bone scan will show __________.	**87.** “double density” sign, a peripheral area of diffusely increased uptake, with a focal central area of more avid uptake
88. Osteogenic sarcoma commonly shows a photon-deficient pattern when it occurs in __________ bone.	**88.** pagetic
89. True or false: With breast carcinoma, flare response is seen in patients who responded to therapy but not in nonresponders.	**89.** True.
90. In prostate cancer patients, low levels of prostate-specific antigen (PSA) correlate with a very low likelihood of bone metastasis, except in those who have had __________ treatment.	**90.** hormonal
91. True or false: Bone labeling is not increased significantly after 30 minutes.	**91.** True.
92. Spot view resolution generally outperforms whole-body acquisition resolution by large detectors capable of single-pass acquisitions. Why is this?	**92.** The crystal is closer to the patient.
93. Metastatic calcification shows intense labeling of the __________.	**93.** lungs and the fundus of the stomach
94. True or false: In cases of Paget’s disease that appears lytic on an X-ray, photopenia is common on a bone scan.	**94.** False.
95. True or false: Extremely intense labeling is characteristic of fibrous dysplasia.	**95.** False.
96. True or false: In acute osteomyelitis, blood flow is increased in the arterial phase.	**96.** True.
97. Neutrophils are resistant to radiation from ^{111}In labeling, whereas lymphocytes are very sensitive to ^{111}In radiation damage. What is the clinical implication of this?	**97.** A lymphocytic response to chronic infection is not excluded by this technique.
98. ^{99m}Tc __________ is superior to other currently used bone agents at localizing necrotic tissue.	**98.** pyrophosphate
99. Vertical linear activity in the posterior ribs is seen in 7% of scans and is secondary to __________.	**99.** the insertion of the iliocostalis portion of the erector spinae muscles
100. Increased uptake in the patellae, the “hot” patellae sign, is usually due to __________.	**100.** degenerative disease
101. Lower cervical activity as a normal variant may be secondary to __________.	**101.** lordosis, thyroid cartilage uptake, or free ^{99m}Tc-pertechnetate in the thyroid gland
102. Free TcO_4 from the breakdown of tag will localize to the __________.	**102.** thyroid gland and gastrointestinal tract

103. Colloid formation during tracer preparation will show activity in the __________.

103. reticuloendothelial system

104. Aluminum contamination during preparation of the radiopharmaceutical results in __________.

104. pulmonary activity

105. True or false: A circular skeletal lesion is more likely to be benign than malignant.

105. True.

106. The uptake of phosphate bone agents is determined by bone metabolic activity, blood flow, and __________.

106. sympathetic tone

107. Loss of __________ leads to an inability to close capillaries, and the resultant increase in blood flow causes increased tracer accumulation, as seen in patients with stroke or hemiplegia.

107. sympathetic tone

108. True or false: Chemotherapy commonly causes decreased kidney uptake.

108. False.

109. In Paget's disease, laboratory findings include increased serum alkaline phosphatase level and elevated serum and urinary __________ levels.

109. hydroxyproline

110. Reflex sympathetic dystrophy (RSD) syndrome is also termed __________.

110. complex regional pain syndrome, causalgia (complex regional pain syndrome), Sudeck's atrophy, or shoulder-hand syndrome

111. Symptoms of RSD include __________.

111. pain, tenderness, vasomotor instability, swelling, and dystrophic skin changes

112. Single-photon emission computed tomography (SPECT) has been shown to have an important role in the evaluation of __________.

112. facial bones, temporomandibular joints, back, and knees

113. The diphosphonates are characterized by __________ bonds instead of the __________ bonds of phosphates.

113. P–C–P; P–O–P

114. What are the advantages of diphosphonates over phosphates?

114. Diphosphonates are more stable in vivo, have a more rapid blood clearance, and yield a higher bone-to-background ratio than phosphates.

115. When is ^{99m}Tc-pyrophosphate (PYP) used?

115. Myocardial infarct avid scan.

116. Why is cold PYP used for radiolabeling red blood cells?

116. It contains stannous chloride, which is a reducing agent that allows Tc-RBC tagging.

117. What are the current agents used for bone scanning?

117. Methylene diphosphonate (MDP) and methylene hydroxydiphosphonate (MHDP).

118. What are the mechanisms of osseous uptake on the bone scan?

118. Chemoabsorption of apatite crystals and incorporation into immature collagen.

119. Which factors influence the degree of uptake in the bone scan?

119. Skeletal blood flow, osteoblastic activity, and calcium turnover.

120. Name three mechanisms of extraosseous uptake of bone agent.

120. Hyperemia: increased delivery; calcification or ossification: bind with phosphonate; and necrosis: calcium influx.

121. What patient factors will reduce the quality of a bone scan?

121. Obesity, congestive heart failure, and renal insufficiency.

122. What is a four-phase bone scan?

122. Additional 24-hour delayed images.

123. What is the significance of positive first and second phases but a normal third phase?

123. Suggestive of soft-tissue process without bone involvement.

124. What is the significance of normal first and second phases but a positive third phase?

124. Bone lesion that is usually chronic, not hypervascular or active.

125. What is the significance of a positive fourth phase?

125. Suggestive of osteomyelitis or malignant tumor rather than arthritis or benign bone disease.

126. When can the three-phase bone scan (3PBS) produce a false-negative?

126. Diminished delivery due to vascular disease or occlusion.

127. If the 3PBS is conclusive for osteomyelitis, what is the benefit of performing an additional gallium scan?

127. Monitoring therapeutic response since a bone scan may remain positive for 1 to 2 years.

128. What is the scintigraphic pattern of osteomyelitis in children?

128. "Hot" focus in metaphyseal region.

129. What is the meaning of a photon defect in the area of an active infection?

129. A photon defect in the area of an active infection may represent an abscess with a necrotic center in advanced osteomyelitis or ischemia associated with early osteomyelitis.

130. What is the scintigraphic finding for pseudoarthrosis?

130. Irregular discrete focal increased uptake at the site of pseudoarthrosis.

131. Other than a bone scan, what nuclear medicine procedure can be used for MO evaluation?

131. Bone marrow scan using ^{99m}Tc-colloid.

132. On a bone marrow scan, what will the scintigraphic finding be for MO evaluation?

132. A mature MO will concentrate radiocolloid, and an immature MO may demonstrate little bone marrow activity.

133. What are the agents used for bone marrow scanning?

133. ^{99m}Tc–albumin colloid, ^{99m}Tc–sulfur colloid, and ^{99m}Tc–antimony colloid.

134. What is a shin splint?

134. Periostitis along the posteromedial angle of the tibia, tear of the tibialis posterior muscle or soleus muscle/tendon complex.

135. What is the usual scintigraphic appearance of a stress fracture?

135. Focal rounded uptake.

136. What is the scintigraphic pattern of septic arthritis in a four-phase bone scan?

136. Diffusely increased flow and blood pool on images in the first and second phases; third phase may be normal or positive; fourth phase normal.

137. What are the scintigraphic findings of cellulitis?	**137.** Increased flow and blood pool on images in the first and second phases; third phase may be normal or positive; fourth phase normal.
138. What are the possible complications of a hip prosthesis?	**138.** Infection, loosening, fracture, heterotopic bone formation, myositis ossificans.
139. How does one evaluate prosthesis problems with nuclear medicine?	**139.** Three-phase bone scan plus labeled white cell or gallium scan if needed
140. What is the scintigraphic finding of loosening of the femoral component?	**140.** Focal skeletal phase uptake at the tip of the hardware.
141. What are the scintigraphic findings of an infected femoral component?	**141.** Increased flow and intense uptake around the prosthesis's stem.
142. What does a discordant gallium bone scan pattern indicate?	**142.** Acute osteomyelitis.
143. How is a radionuclide arthrogram performed?	**143.** Using ^{99m}Tc–albumin colloid in a routine arthrogram procedure.
144. What does one see in a poorly tagged ^{99m}Tc-medronate (MDP) scan?	**144.** Gastric, salivary gland, and thyroid uptake.
145. What are the three most common causes of hepatic visualization in a bone scan?	**145.** Metastases, technical (colloid formation, elevated aluminum impurity), and recent liver–spleen scan.
146. What are two common causes of splenic uptake on a bone scan?	**146.** Sickle cell anemia and recent liver–spleen scan.
147. Name three causes of gastric uptake on a bone scan.	**147.** Free pertechnetate, milk-alkali syndrome, and hypercalcemia.
148. What is the most common cause of thyroid uptake on a bone scan?	**148.** Free pertechnetate.
149. Name three causes of breast uptake on a bone scan.	**149.** Breast cancer, gynecomastia, mastitis, normal variant.
150. Give at least three differentials of cardiac uptake in a bone scan.	**150.** Myocardial infarct, cardiac failure, renal failure, pericardial effusion, pericarditis, amyloidosis, and inadequate interval between injection and scan.
151. Name three causes of focal brain uptake in a bone scan.	**151.** Infarct, metastasis, and abscess.
152. What is the most common cause of skin activity on a bone scan?	**152.** Urine contamination.
153. Give three differentials of generalized decreased osseous uptake in a bone scan.	**153.** Technical (e.g., impurity, poor tagging), osteoporosis, and obesity.
154. Give at least five differentials of focally decreased osseous uptake in a bone scan.	**154.** Avascular necrosis of bone, radiation, lytic metastases, early fracture, bone cyst, early osteomyelitis.
155. Name the four primary tumors causing photopenic metastases.	**155.** Renal, thyroid, multiple myeloma, and lung.
156. Describe the scintigraphic pattern of Paget's disease.	**156.** Expansile bone or thickening of the bone with sharp demarcation from the normal area.
157. How does Paget's disease affect bone?	**157.** Increased bone resorption accompanied by increased bone formation.

158. Describe the scintigraphic pattern of multiple myeloma.

158. Mostly normal; some may reveal diminished uptake, increased uptake at fracture sites.

159. What is the general scintigraphic characteristic of metabolic bone diseases?

159. Diffusely increased bone activity.

160. What is the scintigraphic pattern of benign pleural effusion in bone scans?

160. Diffusely diminished activity of a portion of the thorax.

161. What is the scintigraphic pattern of malignant pleural effusion in bone scans?

161. Increased activity.

162. What is the scintigraphic pattern of radiation osteitis in bone scans?

162. Increased activity in the first several weeks, followed by defect.

163. What is the scintigraphic pattern of extramedullary hematopoiesis in bone scans?

163. Increased uptake, especially in the ribs with paravertebral activity.

164. What is the scintigraphic pattern of early fracture in bone scans?

164. Cold defect within the first few hours.

165. What are the possible explanations for a cold defect in bone scans in the setting of fractures?

165. Rupture of vascular supply from fracture, too early for reactive bone formation.

166. How soon will a fracture become positive, and what is its time course in the bone scan?

166. Cold defect in the first few hours, then increasing activity for up to a few weeks or months, thereafter tapering off until resolved.

167. What is the meaning of a persistent “hot” uptake in a remote fracture?

167. Nonhealing or nonunion, refracture in the same area.

168. What is the role of ^{89}Sr?

168. ^{89}Sr, an analog of calcium, is absorbed in the sites of bone metastases, where it irradiates the lesion, producing palliation of pain for an average of 6 months after a single dose.

169. What are the some of the approved radionuclides used for pain palliation in bone metastases?

169. ^{89}Sr, ^{153}Sm.

170. What is the most common side effect of the use of radionuclides for pain palliation in bone metastases?

170. Bone marrow suppression.

171. The proportion of bone radiopharmaceutical actually picked up by bone is approximately:

a) 10 to 15%
b) 30%
c) 50%
d) 75%
e) 90%

171. c, 50%

172. The clearance of bone radiopharmaceuticals from the blood into the bone’s hydroxyapatite crystal plateaus at approximately:

a) 5 minutes
b) 20 minutes
c) 1 hour
d) 2 hours
e) 3 hours

172. b, 20 minutes

173. Photon-deficient bone scan lesions may be found in:

a) metastatic disease
b) Legg–Calvé–Perthes disease
c) infarct of sickle cell disease
d) osteomyelitis
e) all of the above

174. True or false: Bone scans are more sensitive than radioiodine surveys in detecting metastatic thyroid lesions.

175. Which among the following commonly causes photopenic lesions on a bone scan?

a) Malignant melanoma
b) Ewing's sarcoma
c) Multiple myeloma
d) Hypernephroma
e) Colon carcinoma

176. The injected material most likely to be associated with increased injection site uptake on a bone scan is:

a) insulin
b) vitamin B12
c) Compazine
d) Demerol
e) iron dextran

177. Superscans are generally associated with:

a) several focal areas of increased uptake
b) absent kidney visualization
c) enhanced salivary gland uptake
d) all of the above
e) none of the above

178. Increased uptake of bone tracer in a patient's hemithorax on both anterior and posterior views is most often associated with:

a) postmastectomy state
b) unilateral hyperlucent lung
c) pleural effusion
d) calcific pleuritis
e) all of the above

179. True or false: The chemical structure of organic phosphates, such as MDP, includes a phosphate–carbon (P–C–P) linkage.

180. True or false: A gallium scan showing lesions that are intense and discordantly smaller in distribution than on bone scans is strongly suggestive of osteomyelitis.

173. e, all of the above.

174. False.

175. Both c (multiple myeloma) and d (hypernephroma)

176. e, iron dextran

177. b, absent kidney visualization

178. c, pleural effusion

179. True.

180. True.

For questions 181 through 185, match each statement with the appropriate radiopharmaceutical by choosing from the following: ^{67}Ga-citrate, ^{111}In–white blood cells (WBCs), both, or neither.

181. Best for more acute infection.

182. Has physical half-life close to 3 days.

183. Can best detect extent of edema associated with osteomyelitis.

184. Can be studied with a low-energy collimator.

185. Multiple blood transfusions may cause false-negative study.

181. ^{111}In-WBCs

182. Both

183. Neither

184. Neither

185. ^{67}Ga-citrate

186. True or false: Neuropathic (Charcot) joints are generally associated with proximal hyperemia in the involved extremity on a bone scan.

186. True

187. Splenic uptake on a bone scan is most often seen in:

a) cirrhosis with portal hypertension
b) hypersplenism
c) sickle cell disease
d) lymphoma
e) splenic abscess

187. c, sickle cell disease

188. What is the positron emission tomography (PET) bone agent covered through National Oncologic PET Registry (NOPR)?

188. ^{18}F NaF.

189. What is a DEXA scan?

189. Dual X-ray absorptiometry utilizes X-rays of two discrete energies to estimate the bone mineral density.

190. What is a T score and what is a Z score?

190. Comparison of the bone mineral density to a standard young population represents a T score, whereas age-matched controls provide a Z score.

191. Define osteopenia and osteoporosis criteria on a DEXA scan.

191. A T score of < -1.0 to > -2.5 is consistent with osteopenia; a T score of less than -2.5 is consistent with osteoporosis.

192. In evaluation of osteopenia and osteoporosis, which of the following statement(s) is (are) true?

a) DEXA of L1–L4 spine anteroposterior projection, and femoral neck
b) DEXA forearm measurements predominantly in cases of hyperparathyroidism and obese patients
c) Total body calcium measurement preferred in children
d) DEXA lateral vertebral assessment to identify vertebral fractures
e) All of the above

192. e, all of the above

193. Twenty-seven-year-old woman with right leg pain on running. Radiographs were normal. Blood flow, soft-tissue phase, and delayed skeletal phase images are shown (▶Fig. 5.1a–c).

What is the diagnosis?

a) Normal
b) Arthritis at bilateral ankle joints
c) Stress fracture of right tibia
d) Shin splints of right tibia

193. d

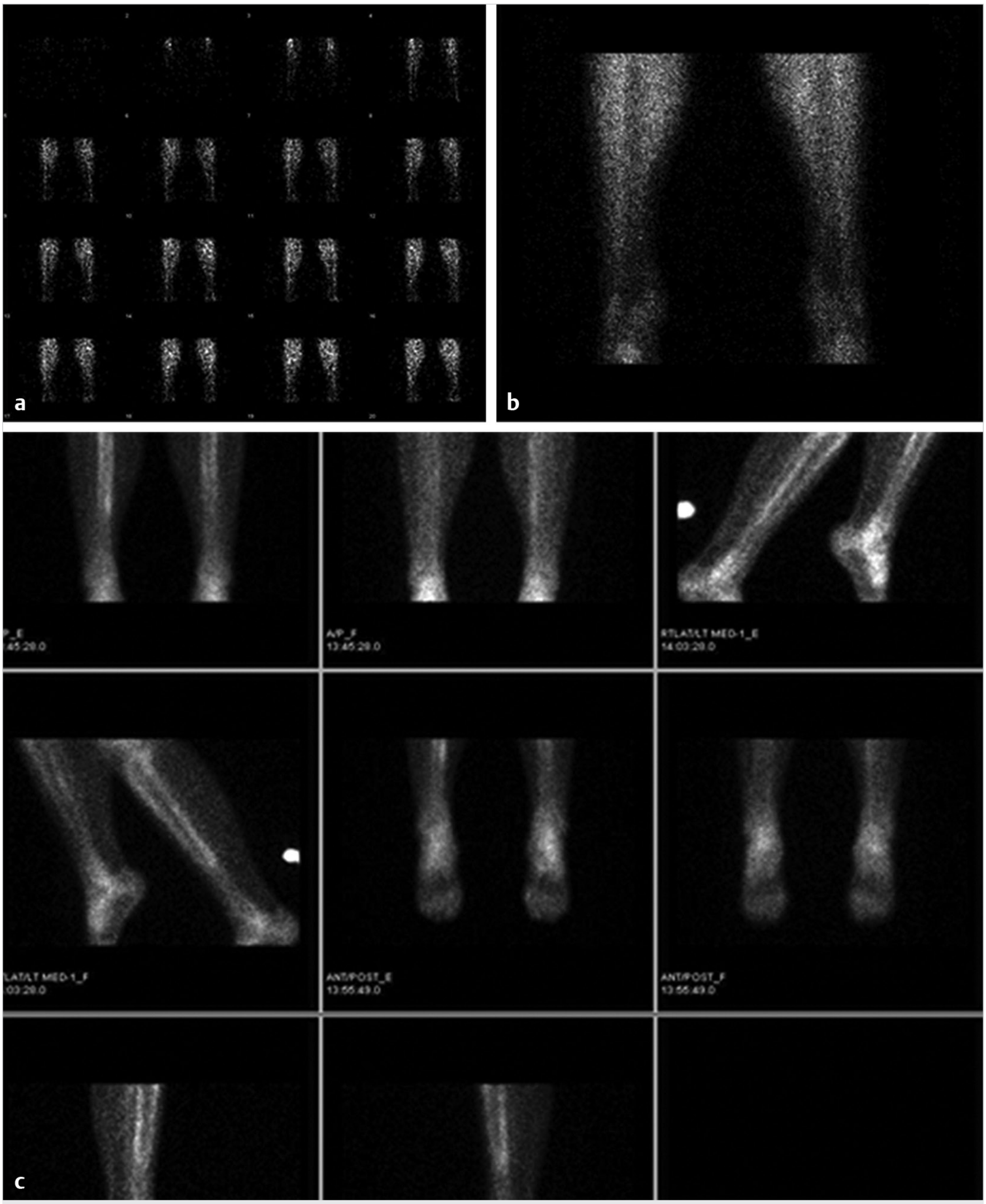

Fig. 5.1

194. The following statements are true for shin splints except:

a) Refer to pain posterior medial of the tibia makes worse by running and improve by resting
b) Repetitive stress brings on periostitis, tear of tibialis posterior, or soleus muscle/tendon complex
c) Radiographs are generally normal
d) Shin splint is a type of fracture

195. Regarding bone scan in shin splints:

a) Usually a three-phase bone scan is performed
b) Blood flow phase shows hyperperfusion
c) Soft-tissue phase shows hyperemia
d) Longitudinal diffuse wavy irregular hyperactivity in the periosteal aspect of the posteromedial tibia greater than one-third of the bone length without focal uptake on skeletal phase

196. Treatment of shin splints includes all of the following except:

a) rest
b) ice
c) surgery
d) NSAIDs (nonsteroidal anti-inflammatory drugs)

197. Twenty-seven-year-old woman complaining of lower extremities pain on running. A three-phase bone scan was done (▶Fig. 5.2).

What is the diagnosis?
a) Bilateral shin splint.
b) Bilateral stress fractures
c) Left stress fracture and right shin splint
d) Right stress fracture and left shin splint

198. Concerning a three-phase bone scan in stress fracture which statement(s) is (are) true?

a) There is generally hyperperfusion
b) There is hyperemia on soft-tissue phase
c) There is focal hyperactivity on skeletal phase
d) There is diffuse hyperactivity on skeletal phase

194. d

195. a and d

196. c

197. b

198. a, b, and c

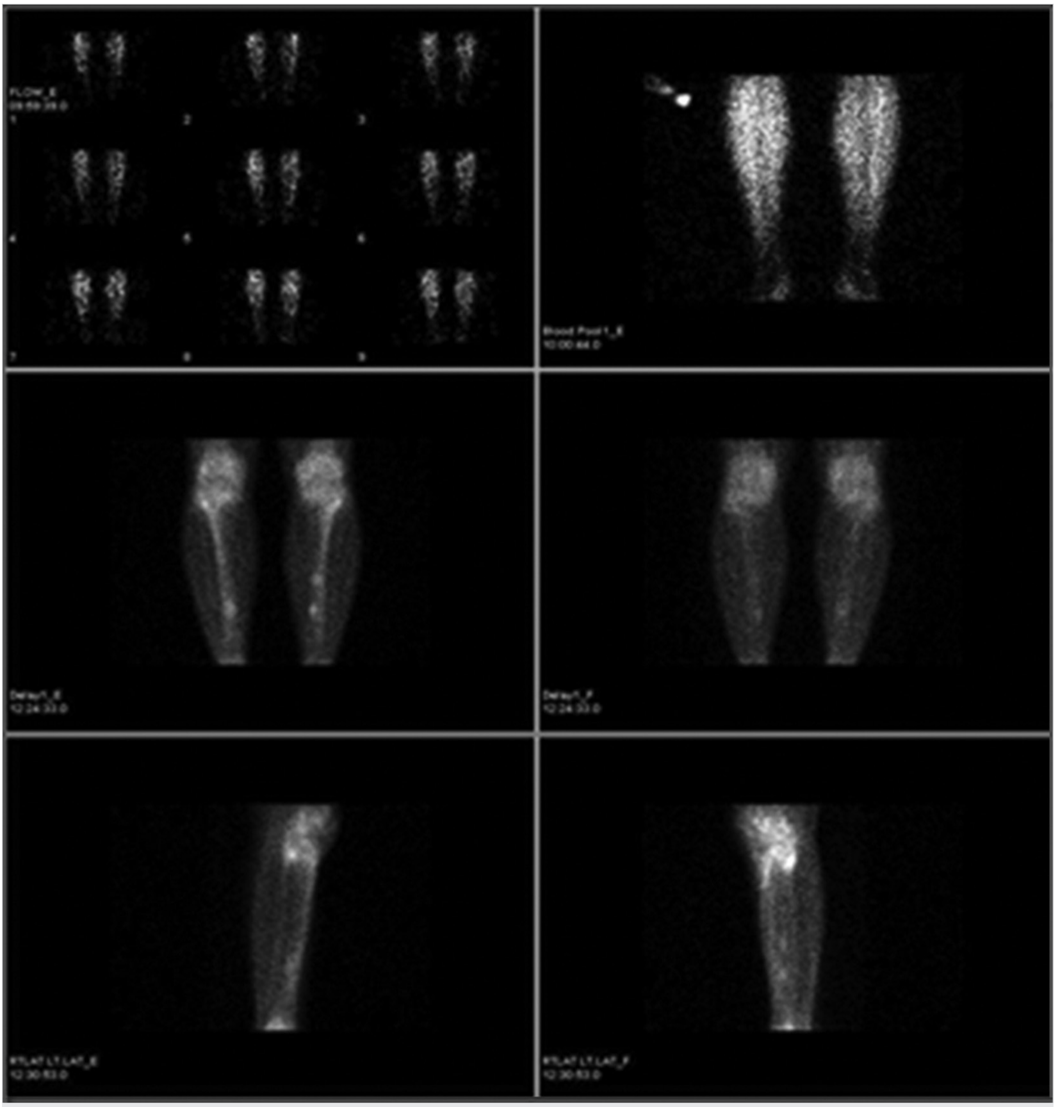

Fig. 5.2

199. Radiographic findings of stress fracture includes:

a) poor sensitivity, usually normal, during acute phase
b) abnormal fracture line during acute phase is rare
c) periosteal reaction weeks later
d) sclerotic line weeks later
e) all of the above

199. e, all of the above

200. Treatment of stress fracture includes the following:

a) off weight-bearing
b) brace
c) crutch
d) rarely surgery
e) all of the above

200. e, all of the above

201. Forty-four-year-old male with history of lung cancer complaining of bone pain. Bone scan was done to rule out bone metastasis (▶Fig. 5.3).

What is the diagnosis?
a) Rhabdomyolysis
b) Diffuse bone metastasis
c) Fractures of femora and tibiae
d) Hypertrophic osteoarthropathy

201. d

202. Disorders associated with hypertrophic osteoarthropathy include all of the following except:

a) intrathoracic malignancy
b) cyanotic congenital heart disease
c) inflammatory bowel disease
d) hypothyroidism

202. d

Fig. 5.3

203. Hypertrophic osteoarthropathy is most commonly associated with:
a) bronchogenic carcinoma
b) gastric carcinoma
c) hepatoma
d) colon carcinoma

203. a

204. In hypertrophic osteoarthropathy, all of the following statements are true except:
a) There is periosteal reaction of long bones of extremities
b) It involves diaphysis and metadiaphysis
c) There is underling bone metastasis
d) There is no bone disease underlining the periosteal reaction

204. c

205. Sixty-year-old male with chronic renal disease on dialysis complaining of diffuse joint pain. Bone scan was done (▶Fig. 5.4).
What is the diagnosis?
a) Diffuse bone metastasis
b) Generalized arthritides
c) Renal osteoarthropathy
d) Normal bone scan

205. a and c

206. Superscan is generally associated with the following except:
a) very high bone-to-background ratio
b) absent or faint kidneys
c) very fast count rate in the axial skeleton
d) several focal increased uptake

206. d

207. The most common neoplastic cause of superscan is:
a) lung carcinoma
b) breast carcinoma
c) colon carcinoma
d) prostate carcinoma

207. d

208. What percentage of a ^{99m}Tc-diphosphonate dose localizes in bone normally?
a) 30%
b) 50%
c) 70%
d) 90%

208. b

209. Fifty-seven-year-old woman with breast carcinoma. Bone scan done to rule out bone metastasis (▶Fig. 5.5a–c).
What of the following is (are) true?
a) Diffuse bone metastasis
b) Normal bone scan
c) Abnormal liver uptake consistent with metastatic mucin producing carcinoma metastasis
d) Liver uptake of Tc99m-MDP due to prior liver–spleen scan

209. c

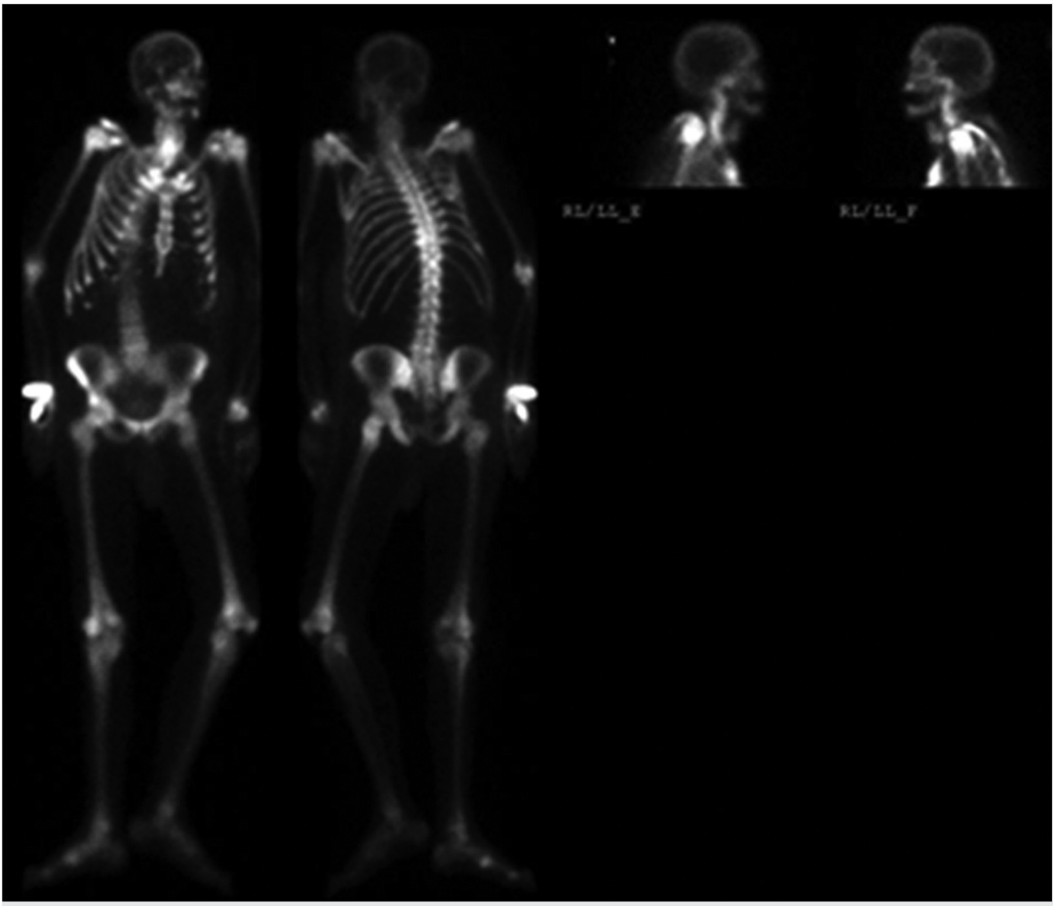
RL/LL_E
RL/LL_F

Fig. 5.4

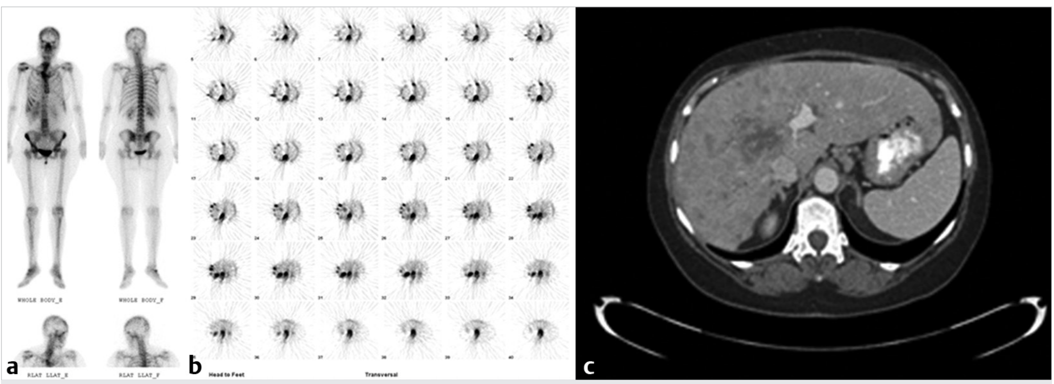
a
WHOLE BODY_E
WHOLE BODY_F
RLAT LLAT_E
RLAT LLAT_F
b
Head to Feet
Transversal
c

Fig. 5.5

210. Etiology of visualization of liver on a bone scan includes:

a) recent liver and spleen scan
b) metastatic carcinoma from breast carcinoma
c) metastatic carcinoma from colon carcinoma
d) radiocolloid formation from molybdenum breakthrough
e) all of the above

211. On a bone scan, liver uptake caused by dystrophic ossification is most often due to:

a) hyperparathyroidism
b) metastatic colon carcinoma
c) hemosiderosis
d) metastatic melanoma

212. Concerning Tc99m-diphosphonate, the following statement(s) is (are) true:

a) Introduction of oxygen into a vial of ^{99m}Tc-diphosphonate causes formation of colloidal and free Tc.
b) ^{99m}Tc-diphosphonate that does not localize in bone is cleared from the body by glomerular filtration.
c) The critical organ from the bone scan is kidney.
d) Kidney has increased uptake in a bone scan when the uptake is more than in lumbar spine uptake.

213. Eighty-four-year old woman with history of breast carcinoma and elevated alkaline phosphatase level. Bone scan to evaluate for bone metastasis (▶Fig. 5.6a, b).

Which of the statements is/are true?
a) Bone metastasis to skull
b) Paget’s disease of the skull
c) Hyperostosis frontalis interna
d) Bone scan shows decreased uptake in osteoporosis circumscripta

214. Common causes of diffuse calvarial uptake in a bone scan include the following except:

a) hyperostosis
b) marrow expansion
c) Paget’s disease
d) bone metastasis

215. Uptake that starts at the end of a long bone and extends well into the diaphyseal shaft is most typical of:

a) fibrous dysplasia
b) Paget’s disease
c) osteomyelitis
d) osteonecrosis

210. e, all of the above

211. b

212. a, b, and d. Urinary bladder is the critical organ.

213. b

214. d

215. b

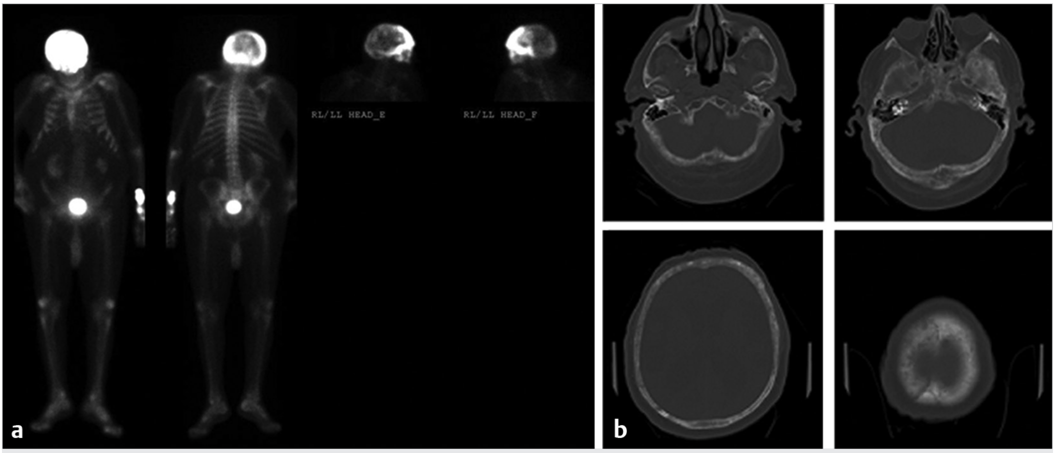

Fig. 5.6

216. The following statements are true of Paget's disease except:

a) increased bone resorption accompanied by increased bone formation
b) elevated serum alkaline phosphatase
c) elevated serum and urinary hydroxyproline
d) malignant degeneration to sarcoma occurs in 5 to 10% of patients

217. Sixteen-year-old boy with right knee pain. Three-phase bone scan including SPECT of delayed skeletal phase (▶Fig. 5.7a, b).

Differential diagnosis should include:

a) avascular necrosis of right femoral condyle epiphysis
b) osteochondritis dissecans of right femoral condyle epiphysis
c) normal bone scan
d) avascular necrosis of left femoral condyle epiphysis

218. Concerning acute phase of avascular necrosis of bone (AVN), which of the following statement(s) is (are) true?

a) There is hyperperfusion on blood flow phase, hyperemia on soft-tissue phase, and hyperactivity on delayed skeletal phase
b) There is hypoperfusion on blood flow phase and hypoactivity on delayed skeletal phase
c) There is hyperperfusion on blood flow phase, hyperemia on soft-tissue phase, and hypoactivity on delayed skeletal phase
d) There is hypoperfusion on blood flow phase and hyperactivity on delayed skeletal phase

216. d

217. a and b

218. b

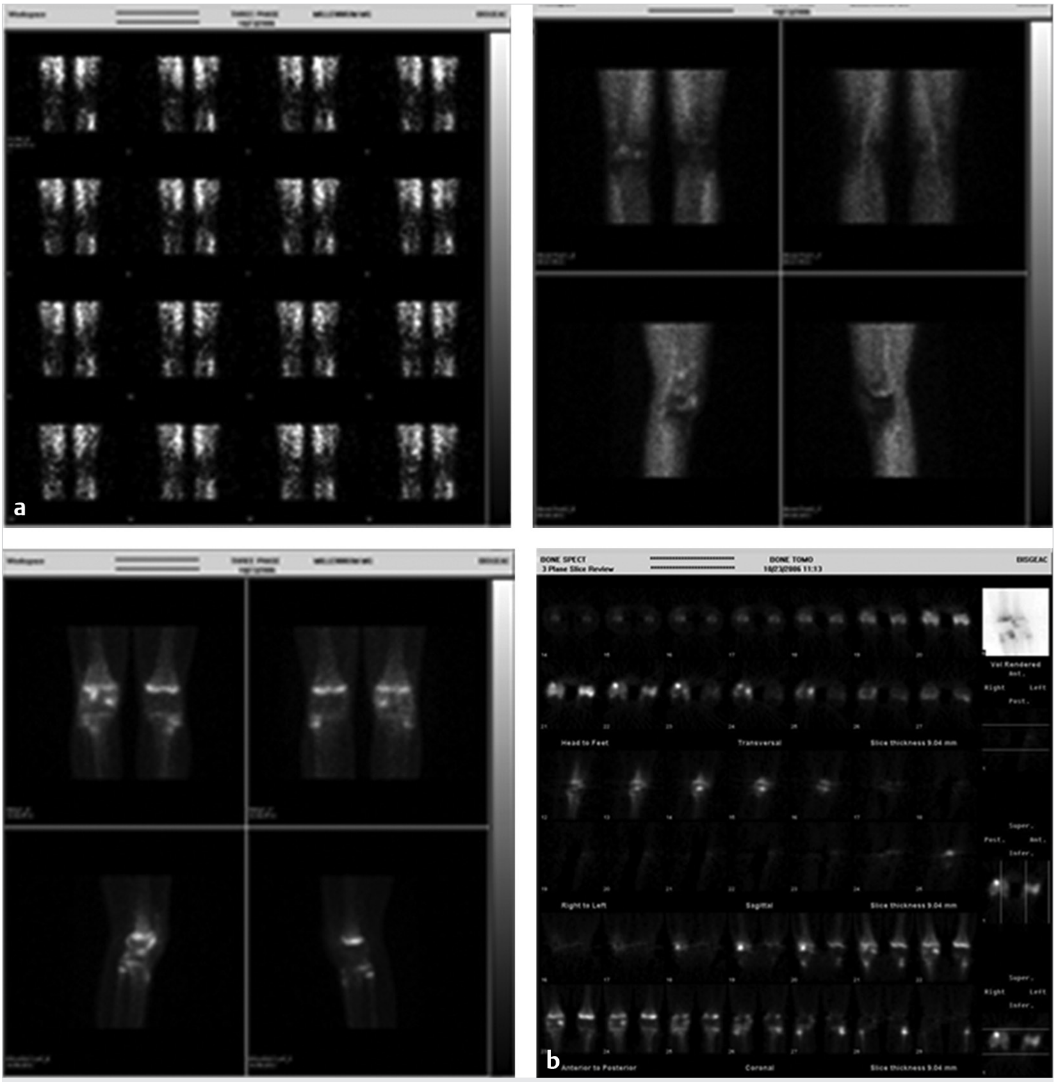

Fig. 5.7

219. Concerning chronic/reparative phase of AVN, which of the following statement(s) is (are) true?

a) There is hyperperfusion on blood flow phase and hyperactivity on delayed skeletal phase
b) There is normal blood flow phase and hyperactivity on delayed skeletal phase
c) There is hypoperfusion on blood flow phase and hypoactivity on delayed skeletal phase
d) There is hypoperfusion on blood flow phase and hyperactivity on delayed skeletal phase

219. a and b

220. Concerning bone marrow scan in AVN, which of the following statement(s) is (are) true?

a) Hypoactivity on bone marrow scan in area of hypoactivity on bone scan consistent with chronic/reparative phase AVN
b) Hypoactivity on bone marrow scan in area of hyperactivity on bone scan consistent with chronic/reparative phase AVN
c) Hyperactivity on bone marrow scan in area of hyperactivity on bone scan consistent with chronic/reparative phase AVN
d) Hyperactivity on bone marrow scan in area of hypoactivity on bone scan consistent with chronic/reparative phase AVN

220. b

221. Eighty-one-year-old man with left lung mass likely malignant. Bone scan to rule out bone metastasis (▶Fig. 5.8a, b).

What of the following is (are) true?

a) Normal bone scan.
b) Asymmetry of uptake in right and left hemithoraces is due to positional artifact.
c) Increased uptake in left hemithorax is due to exudative pleural effusion.
d) Upper pole of right kidney is laterally deviated by a large renal cyst.

221. c and d

222. Concerning pulmonary uptake in a bone scan, all of the following statements are true except:

a) malignant pleural effusion
b) hypercalcemia
c) microlithiasis
d) transudative pleural effusion

222. d

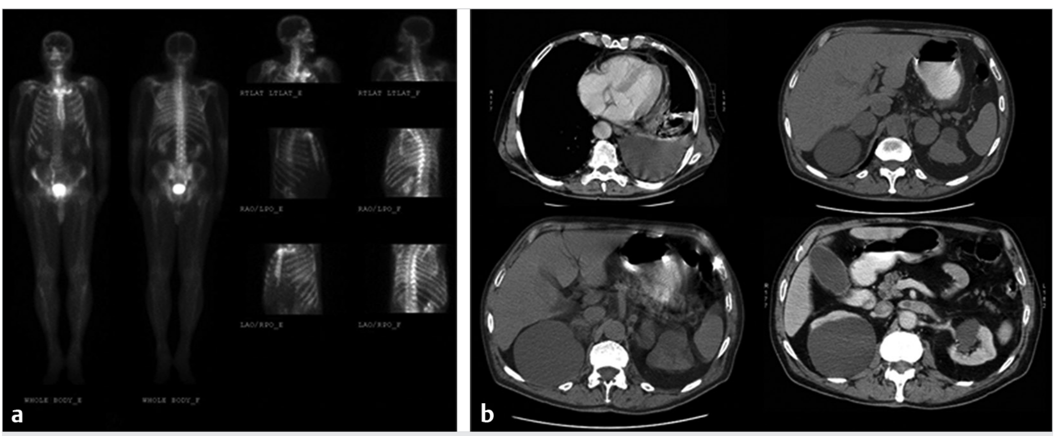

Fig. 5.8

223. Among the following neoplasms, which cancer is least likely to metastasize to bone (as compared with the others)?

a) Ovary
b) Prostate
c) Lung
d) Breast

224. Uptake in lungs, stomach, heart, and enhanced kidney activity on a bone scan is often seen in patients with:

a) myelosclerosis
b) hyperthyroidism
c) metastases from osteogenic sarcoma
d) hyperparathyroidism

225. Thirty-six-year-old woman complains of right hand numbness, pain, and pinprick sensation (▶Fig. 5.9a–c). She had right hand surgery 6 months prior.

What is a most likely diagnosis?

a) Normal three-phase bone scan.
b) Findings are most consistent with osteomyelitis of the right hand.
c) Findings are most consistent with complex reflex sympathetic dystrophy (RSD).
d) Findings are most consistent with septic arthritis of right hand.

223. a

224. d

225. c

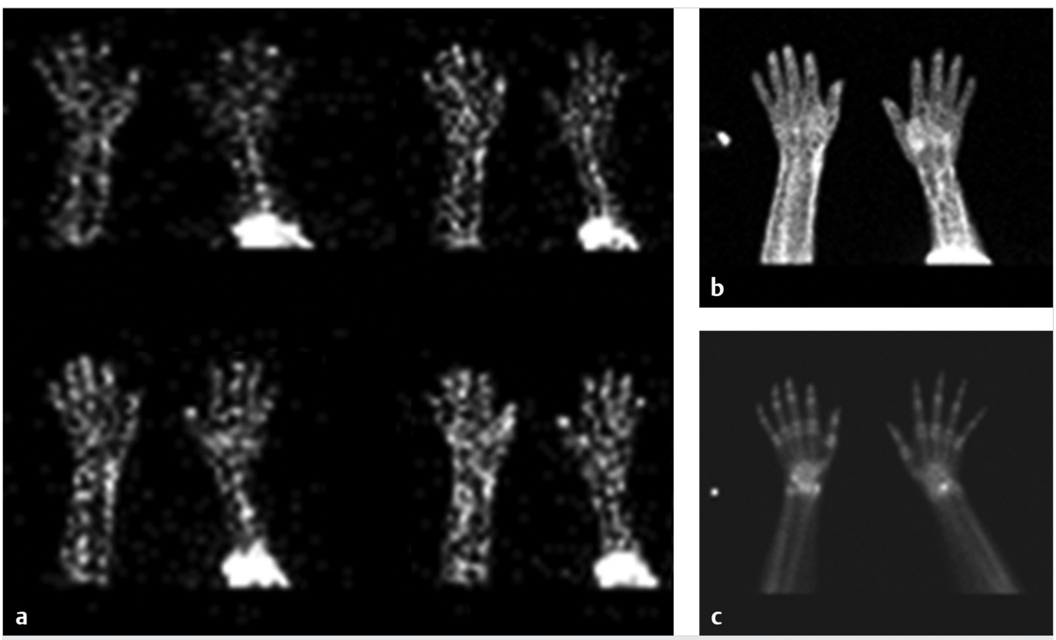

Fig. 5.9

226. Scintigraphic findings for RSD include:

a) increased blood flow
b) increased soft-tissue activity
c) increased periarticular activity in delayed images
d) normal delayed images

226. a, b, and c

227. Concerning RSD, all of the following statements are true except:

a) Loss of sympathetic stimulation results in vasodilatation, increased blood flow, and bone turnover.
b) There is associated synovitis contributing to the diffusely increased periarticular activity.
c) In hemiplegic, the flow may be decreased due to diminished metabolic demand (disused), but there will be increased periarticular uptake.
d) In hemiplegic, the flow may be decreased due to diminished metabolic demand (disused), and there will be decreased periarticular uptake.

227. d

228. Unilateral increased uptake in a distal extremity on a bone scan may be associated with:

a) paralysis of a limb
b) reflex sympathetic dystrophy
c) intra-arterial injection
d) all of the above

228. d

229. Forty-six-year-old woman with breast carcinoma was diagnosed to have bone metastasis on bone scan dated May 18, 2016 (▶Fig. 5.10). She was put on chemotherapy and repeat bone scan dated September 15, 2016.

What is the most likely diagnosis?

a) Bone metastasis with progression
b) Bone metastasis with flare phenomenon
c) Either bone metastasis with progression or bone metastasis with flare phenomenon
d) Bone metastasis with regression

229. a

230. Concerning the flare phenomenon in bone scan, which of the following statement(s) is (are) true?

a) It represents worsening metastatic disease.
b) It represents "healing" response to chemotherapy.
c) It represents a renewed growth of metastatic lesions following hormonal suppression.
d) It represents regression of the metastasis.

230. b

Fig. 5.10

231. How long does it usually take for flare phenomena to normalize?

a) 3 months
b) 6 months
c) 9 months
d) 12 months

231. b

232. From the two bone scans above with 4 months in between, what finding(s) is (are) differentiate finding(s) between flare phenomenon and progression of worsening metastatic disease?

a) There are more lesions on the follow-up study.
b) The lesions seen on the previous scan are more intense and extensive on the current study.
c) There is evidence suggesting the presence of malignant effusion.
d) None of the above.

233. (See ▶Fig. 5.11)

Imaging findings are most consistent with the below diagnosis:

a) insufficiency fracture
b) sternal metastasis
c) postradiation changes
d) spinal metastases

Fig. 5.11

232. c

233. c

234. Review three-phase bone scan and In-111 images and choose the best answer (▶Fig. 5.12a–c).

Findings suggest:
a) aseptic loosening
b) septic loosening
c) suprapatellar joint effusion
d) thrombophlebitis

234. a

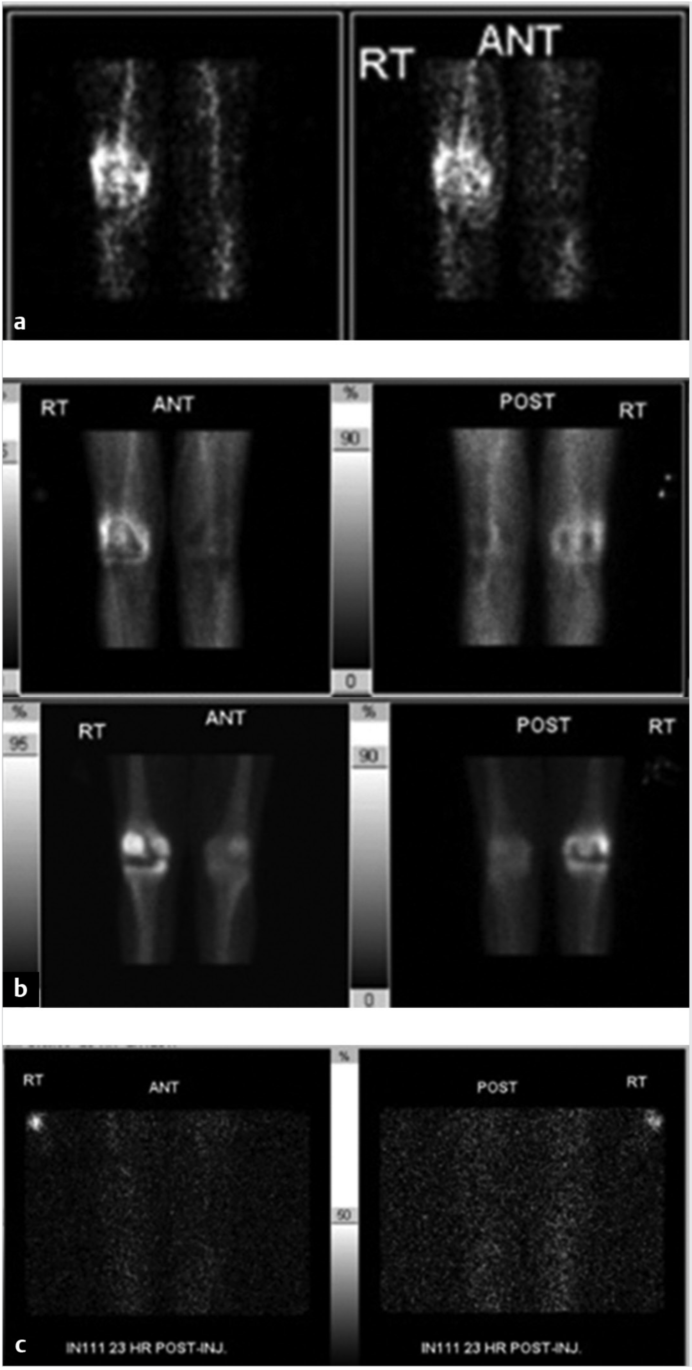

Fig. 5.12

235. Eighty-two-year-old man has history of prostate carcinoma (▶Fig. 5.13).

Findings suggest:

a) free technetium
b) metastatic right axillary lymph node
c) hypertrophic osteoarthropathy
d) extravasation

235. d

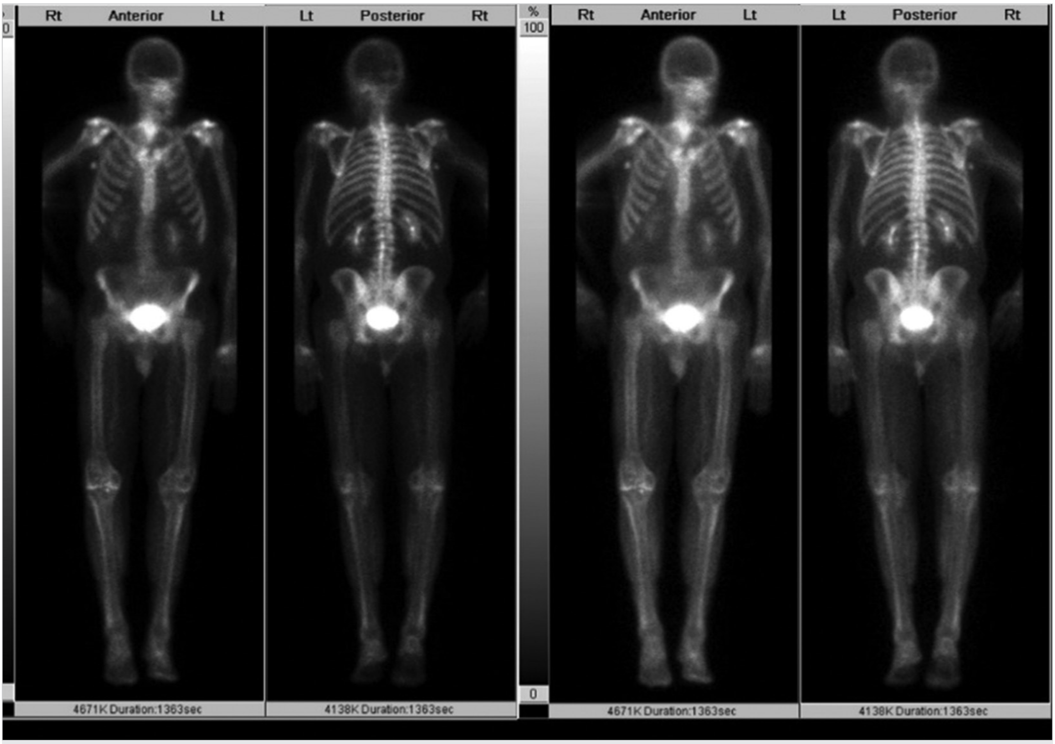

Fig. 5.13

236. Review blood pool and delayed images (▶Fig. 5.14).

Findings suggest:

a) femoral metastases
b) vitamin D deficiency
c) bisphosphonate-associated fracture
d) contamination

236. c

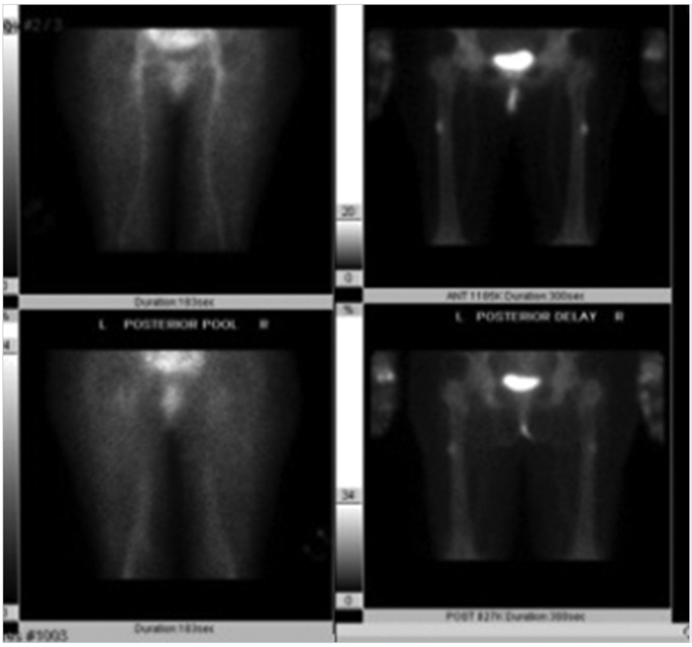

Fig. 5.14

6 Cardiac

Questions

1. What intracellular ion does thallium (Tl) most closely mimic?
2. What is the half-life of ^{201}Tl?
3. How does ^{201}Tl decay?
4. What element does ^{201}Tl decay to?
5. True or false: The photons used for ^{201}Tl imaging come from the decay of ^{201}Tl.
6. What are the energies and abundances of the photons used for ^{201}Tl imaging?
7. What percentage of ^{201}Tl entering the coronary circulation is extracted by the myocardium?
8. What is the relationship between ^{201}Tl extraction by the myocardium and coronary blood flow at physiologic flow rates?
9. What happens to the extraction efficiency of ^{201}Tl at very high flow rates?
10. What happens to the extraction efficiency of ^{201}Tl at very low flow rates?
11. How much of an injected dose of ^{201}Tl remains in the blood 5 minutes after injection?
12. When does peak uptake in the myocardium occur after injection of ^{201}Tl?
13. What is the difference between early and delayed ^{201}Tl uptake?
14. What are the two causes of decreased uptake on early ^{201}Tl images?
15. What is the cause of reduced uptake on delayed ^{201}Tl images?
16. What is the cause of reduced uptake on poststress images with fill-in on delayed images?
17. What patient preparation is recommended for ^{201}Tl imaging?

Answers

1. Potassium.
2. 73 hours.
3. Electron capture.
4. ^{201}Hg (mercury-201).
5. False (they come from the decay of ^{201}Hg).
6. 69 to 83 keV (95% abundance), 135 keV (3.5% abundance), and 167 keV (10% abundance).
7. 88%
8. A linear increase in ^{201}Tl uptake proportional to coronary blood flow.
9. It increases.
10. It decreases.
11. 5%.
12. Peak uptake occurs in 10 to 20 minutes.
13. Early uptake represents blood flow; delayed uptake represents redistribution to equilibrium.
14. Reduced blood flow or absence of viable myocardium (scar).
15. Scar.
16. Myocardial ischemia.
17. The patient should fast for 4 hours before injection.

18. Why should ^{201}Tl injection be as close as possible to a direct venous injection?	**18.** To prevent adsorption to intravenous tubing or to venous structures being exposed to medications.
19. What is the usual initial dose of ^{201}Tl for myocardial imaging?	**19.** 2.0 to 3.5 mCi (74.0–129.5 MBq).
20. When is imaging begun after a dose of ^{201}Tl for myocardial imaging?	**20.** 2 to 5 minutes.
21. What type of collimator is used for ^{201}Tl for planar myocardial imaging?	**21.** Low-energy, high-resolution, or low-energy all-purpose collimator.
22. What are the choices for energy windows for imaging of ^{201}Tl for myocardial imaging?	**22.** A 20 to 25% asymmetric window centered at 80 keV or a 20% symmetric window centered at 69 to 83 keV, and an optional 20% window centered at 167 keV.
23. What is the advantage of using an asymmetric window centered at 80 keV for ^{201}Tl imaging?	**23.** This reduces measurement of scattered higher-energy K-α ^{201}Hg X-rays scattered in the energy range of the lower-energy ^{201}Hg K-βX-rays.
24. What is the advantage of using a 20% window centered at 167 keV for ^{201}Tl imaging?	**24.** It will increase the count rate by 10%.
25. What type of collimator is used for ^{201}Tl in single-photon emission computed tomography (SPECT) myocardial imaging?	**25.** Low-energy, high-resolution, or low-energy all-purpose collimator.
26. What are typical details of a SPECT acquisition for ^{201}Tl myocardial imaging?	**26.** 180-degree arc from 45-degree right anterior oblique to 135-degree left posterior oblique, with imaging completed in 20 to 35 minutes. (Acquisition details differ among camera systems.)
27. What is apical thinning on ^{201}Tl myocardial imaging?	**27.** Physiologically reduced uptake in the apex.
28. What kind of attenuation artifact is commonly seen in women on ^{201}Tl myocardial imaging?	**28.** Anterior wall reductions in uptake, due to breast attenuation.
29. What artifact does diaphragmatic attenuation cause on imaging?	**29.** Decreased uptake in the inferior wall.
30. What is the only organ of the body that does not take up ^{201}Tl?	**30.** The brain. (Thallium does not cross the blood–brain barrier.)
31. Which organs (other than the heart) normally accumulate ^{201}Tl?	**31.** Salivary glands, thyroid gland, skeletal muscles, and kidneys.
32. How is ^{201}Tl myocardial imaging used for risk stratification and prognosis after myocardial infarction?	**32.** Patients with larger infarcts and/or marginal ischemia are at higher risk of mortality.
33. What is stunned myocardium?	**33.** Injured myocardium that is distal to a lysed thrombus that has normal ^{201}Tl uptake but is akinetic on wall motion studies.
34. What is hibernating myocardium?	**34.** Chronically ischemic myocardium that is viable but appears cold on immediate ^{201}Tl images and is akinetic on wall motion studies.

35. What is the rationale for using exercise in ^{201}Tl myocardial perfusion imaging?

35. Normal coronary arteries dilate during exercise and flow increases, while stenotic vessels do not dilate and flow does not increase to the same degree as in normal myocardium.

36. How does one calculate the maximum predicted heart rate?

36. 220 minus age (in beats per minute).

37. How do you calculate the double product of an exercise stress test?

37. Maximum systolic blood pressure multiplied by maximum heart rate.

38. What should be done with cardiac drugs before a ^{201}Tl stress test?

38. They should be stopped at the discretion of the patient's attending physician.

39. How do planar stress ^{201}Tl myocardial images differ from rest images?

39. On the stress images, the target-to-background ratio is higher, right ventricular activity is commonly seen, and less activity is seen in the liver and abdominal structures.

40. What is the meaning of normal ^{201}Tl myocardial uptake on rest and poststress images?

40. Normal myocardium.

41. What is the meaning of reduced ^{201}Tl myocardial uptake on the poststress images and normal uptake on the rest images?

41. Ischemic myocardium.

42. What is the meaning of reduced ^{201}Tl myocardial uptake on the poststress images and improved uptake on the rest images?

42. Ischemic myocardium, possibly with scar.

43. What is the meaning of reduced ^{201}Tl myocardial uptake on the poststress images and the same uptake on the rest images?

43. Scar.

44. Which three items should be described for myocardial perfusion defects?

44. Location, size, and severity.

45. What is the term for normal ^{201}Tl myocardial uptake on the stress images and reduced uptake on the redistribution images?

45. Reverse redistribution.

46. Which areas of the myocardium are served by the left circumflex coronary artery?

46. The lateral and posterior walls.

47. What two findings, other than myocardial defects, should be described on ^{201}Tl myocardial perfusion imaging?

47. Left ventricular dilation and pulmonary uptake.

48. What is "bull's-eye analysis" of ^{201}Tl myocardial perfusion imaging?

48. A quantitative presentation of myocardial uptake and washout.

49. Why is the specificity of ^{201}Tl myocardial perfusion imaging difficult to measure?

49. Only patients with positive or equivocal myocardial perfusion imaging are sent for cardiac catheterization.

50. What is the sensitivity of ^{201}Tl myocardial perfusion imaging for the detection of coronary artery disease among patients without a previous history of coronary artery disease who exercise adequately?

50. 80 to 85%.

51. How is ^{201}Tl myocardial perfusion imaging used to manage the patient with an acute myocardial infarction?

51. Patients with a single fixed defect are given medical therapy; all others are considered for more invasive evaluation and therapy, because they are at higher risk for subsequent cardiac events and death.

52. How is ^{201}Tl myocardial perfusion imaging used to assess a patient with a previous coronary artery bypass or angioplasty?

52. Successful revascularization results in no areas of ischemia, scars will not be affected by revascularization, and perioperative infarction of an ischemic area will appear as a fixed defect.

53. What is the rationale for reinjection of ^{201}Tl before delayed myocardial perfusion imaging?

53. 15 to 35% of ischemia segments do not fill in or normalize by 4 to 5 hours.

54. What enzyme does dipyridamole inhibit?

54. Adenosine deaminase.

55. What is the main advantage of adenosine over dipyridamole?

55. Adenosine has a shorter plasma half-life than dipyridamole.

56. What are the main symptoms and side effects of adenosine and dipyridamole?

56. Chest pain, shortness of breath, hypotension, nausea, vomiting, dizziness, headache.

57. What is the antidote of dipyridamole?

57. Aminophylline, 125 to 250 mg IV.

58. What additional patient preparation is required for patients undergoing stress testing with adenosine or dipyridamole?

58. Patients must be off methylxanthines (e.g., theophylline) and caffeine.

59. Where in the myocardial cell does ^{99m}Tc-sestamibi localize?

59. The mitochondrion.

60. How much of a dose of ^{99m}Tc-sestamibi remains in the blood at 10 minutes after injection?

60. Approximately 5%.

61. What is the clearance time of ^{99m}Tc-sestamibi from the myocardium?

61. 5 hours.

62. What is the usual dose of ^{99m}Tc-sestamibi for myocardial perfusion imaging?

62. 10 to 30 mCi (370–1,110 MBq).

63. What is the advantage of performing gated SPECT and first-pass radionuclide angiography with ^{99m}Tc-sestamibi myocardial perfusion imaging?

63. Both ventricular function and myocardial perfusion can be assessed with a single dose of the radiopharmaceutical.

64. What doses of ^{99m}Tc-sestamibi are used for a 1-day rest/stress myocardial perfusion imaging protocol?

64. Approximately 10 mCi (370 MBq) for rest imaging, followed by 30 mCi (1,110 MBq) for stress imaging.

65. What doses of ^{99m}Tc-sestamibi are used for a 2-day rest/stress or stress/rest myocardial perfusion imaging protocol?

65. Approximately 30 mCi for both rest and stress imaging.

66. How do the diagnostic criteria for infarction and ischemia differ between ^{201}Tl and ^{99m}Tc-sestamibi?

66. In fact, they do not differ.

67. What is the difference between first-pass study of cardiac ventriculography and equilibrium cardiac ventriculography?

67. In first-pass studies, all data collection occurs during the initial transit of tracer through the heart; in equilibrium studies, data are collected over many cardiac cycles using the tracer that remains in the blood pool.

68. What is the radiopharmaceutical of choice for equilibrium-gated blood pool imaging?

68. ^{99m}Tc-labeled red blood cells (RBCs).

69. What are the names of the three different methods for labeling red blood cells (RBCs) with ^{99m}Tc?

69. In vivo, modified in vivo, and in vitro.

70. How is in vivo labeling of RBCs with ^{99m}Tc performed?

70. The patient is injected with cold stannous pyrophosphate; 15 to 30 minutes later, the patient is injected with ^{99m}Tc-pertechnetate.

71. Where in the RBC does ^{99m}Tc bind?

71. To the beta (β) chain of hemoglobin.

72. What is the labeling yield of the in vivo method for labeling RBCs with ^{99m}Tc?

72. Approximately 80% and as low as 60 to 65%.

73. What are five causes of poor in vivo RBC labeling?

73. Drug interactions, circulating antibodies, incorrect amount of stannous ion, excess carrier ^{9m}Tc, and inappropriate procedure.

74. What are six drugs that can cause poor in vivo RBC labeling?

74. Heparin, iodinated contrast media, doxorubicin, methyldopa, hydralazine, and quinidine.

75. How can poor labeling of RBCs be detected?

75. By excessive gastric, thyroid, and soft-tissue uptake.

76. How is modified in vivo labeling of RBCs with ^{99m}Tc performed?

76. The patient is injected with cold stannous pyrophosphate; 15 to 30 minutes later, 3 to 5 mL of blood is withdrawn into an anticoagulated syringe containing ^{99m}Tc-pertechnetate. The syringe is incubated for 10 minutes; the patient is then injected with the contents of the syringe.

77. What is the labeling yield of the modified in vivo method for labeling RBCs with ^{99m}Tc?

77. Approximately 90% or greater.

78. How is in vitro labeling of RBCs with ^{99m}Tc performed?

78. Blood is withdrawn into an anticoagulated syringe; the blood is added to a reaction vial containing stannous chloride; after incubation, sodium hypochlorite is added to the vial and incubated; the last step is adding TcO_4^- to the reaction vial.

79. What is the labeling yield of the in vitro method for labeling RBCs with ^{99m}Tc?

79. Approximately 97% or greater.

80. What non–red cell agent is available for equilibrium-gated blood pool imaging?

80. ^{99m}Tc–human serum albumin.

81. What is the advantage of ^{99m}Tc–human serum albumin over ^{99m}Tc-labeled RBCs?

81. ^{99m}Tc–human serum albumin can be prepared more rapidly.

82. What is the disadvantage of ^{99m}Tc–human serum albumin over ^{99m}Tc-labeled RBCs for equilibrium-gated blood pool imaging?

82. ^{99m}Tc–human serum albumin has more liver uptake and less blood pool activity.

83. What is the main difference in the pharmacokinetics of ^{99m}Tc-labeled RBCs versus ^{99m}Tc–human serum albumin?

83. ^{99m}Tc-labeled RBCs circulate with an effective half-life close to 6 hours, whereas ^{99m}Tc–human serum albumin leaks into the interstitium with a half-life of 4 hours.

84. What are the critical organ and dose for intravenous ^{99m}Tc-labeled RBC?

84. The spleen; 0.11 rad/mCi (0.03 mGy/MBq).

85. What agents may be used for first-pass imaging?

85. Any red blood cell agent (^{99m}Tc-diethylenetriamine pentaacetic acid, ^{99m}Tc-pertechnetate, ^{99m}Tc–sulfur colloid, or almost any other ^{99m}Tc agent).

86. What kind of intravenous injection is required for a first-pass radionuclide angiogram?

86. The injection must be in a compact bolus.

87. Which vein of the arm is preferred for injection in a first-pass radionuclide angiogram?

87. A medial vein in the basilic system in the antecubital fossa. (The cephalic veins should be avoided.)

88. How many frames per second should be obtained for a first-pass radionuclide angiogram?

88. 15 to 30.

89. How much data acquisition time is typically required for a first-pass radionuclide angiogram?

89. 30 seconds.

90. In what situations should the data acquisition time for a first-pass radionuclide ventriculography be performed?

90. All clinical indications, except measuring and/or monitoring left ventricular function before, during, or after chemotherapy.

91. What is the best camera position for assessing right and left ventricular function during a first-pass radionuclide angiogram?

91. A 20-degree right anterior oblique view to separate the atria from the ventricles.

92. What are two advantages of first-pass radionuclide angiography over equilibrium-gated blood pool imaging?

92. Acquisition time is short, allowing imaging at peak stress; the right ventricular ejection fraction can be measured.

93. What is the major disadvantage of first-pass radionuclide angiography over equilibrium-gated blood pool imaging?

93. Low counting statistics.

94. What is used as the gating signal for equilibrium-gated blood pool imaging?

94. The R wave of the electrocardiogram.

95. How many frames are obtained for a typical equilibrium-gated blood pool imaging study?

95. 16 to 24 frames.

96. What is the typical duration of a frame in equilibrium-gated blood pool imaging?

96. Approximately 40 to 50 ms.

97. What are the advantage and disadvantage of increasing the number of frames in equilibrium-gated blood pool imaging?

97. More frames increase temporal resolution, but counting statistics in each individual frame are reduced.

98. How many cardiac cycles are acquired in a typical equilibrium-gated blood pool imaging study?

98. 100 to 300 cycles.

99. How many counts are acquired per image in a typical equilibrium-gated blood pool imaging study?

99. 250,000 counts

100. How do dysrhythmias affect the quality of an equilibrium-gated blood pool imaging study?

100. They degrade the study because segments of the cardiac cycle that are added together do not correspond.

101. What electrocardiogram (ECG) patterns on a rhythm strip will degrade an equilibrium-gated blood pool imaging study?

101. Atrial fibrillation with an irregular ventricular response, skeletal muscle activity, giant T waves, pacemaker artifacts.

102. Which two computer techniques can be used to limit the amount of degradation from dysrhythmias in an equilibrium-gated blood pool imaging study?

102. Filtering data from premature contractions and postextrasystolic beats, and list mode acquisition.

103. What views are typically obtained for a resting equilibrium-gated blood pool imaging study?

103. A 10-degree right posterior oblique, a 30- to 60-degree left anterior oblique, and a left posterior oblique.

104. How should one determine the angulation for a left anterior oblique image for an equilibrium-gated blood pool imaging study?

104. Adjust the angle until the left and right ventricles are maximally separated.

105. What are the common features of the protocols for exercise radionuclide ventriculography?

105. One image is taken at rest, and at least one other image is taken during peak stress.

106. How does one assess wall motion on a radionuclide ventriculogram?

106. Observe the study in a repetitive ciné loop and look for shrinkage of the ventricle at its periphery and thickening of the septum.

107. What is akinesis?

107. The absence of ventricular contraction.

108. What is hypokinesis?

108. Reduced ventricular contraction.

109. What is dyskinesis?

109. Outward ventricular movement during contraction.

110. What is tardokinesis?

110. Ventricular contraction that is present but delayed in timing.

111. Which walls of the left ventricle have the greatest excursion?

111. The free wall and apex.

112. What is the typical wall motion appearance of a myocardial scar?

112. Akinesis or hypokinesis.

113. What is the typical wall motion appearance of myocardial ischemia?

113. Akinesis or hypokinesis.

114. Qualitative analysis of a radionuclide angiogram should assess which four features?

114. Cardiac chamber size, regional wall motion, overall biventricular performance, and extracardiac abnormalities.

115. What is the principal assumption underlying the measurement of left ventricular ejection fraction on a radionuclide ventriculogram?

115. The activity from the heart is directly proportional to ventricular volume.

116. Which frame of a radionuclide ventriculogram is the end-systolic frame?

116. The frame with the fewest counts in the left ventricular region of interest.

117. Which frame of a radionuclide ventriculogram is the end-diastolic frame?

117. The frame with the most counts in the left ventricular region of interest.

118. What is the formula for the left ventricular ejection fraction on a radionuclide ventriculogram?

118. Ejection fraction = (end diastolic counts – end systolic counts)/(end diastolic counts – background counts).

119. What is the usual range for a normal left ventricular ejection fraction measured by a radionuclide ventriculogram?

119. 55 to 75%.

120. Why do the trailing frames of a radionuclide ventriculogram have fewer counts?

120. Because of slight variations in the length of the cardiac cycle.

121. What is the cause of a large fall-off in the counts on trailing frames of a radionuclide ventriculogram?

121. The wide variation in cardiac cycle length, as in atrial fibrillation.

122. How does a computer create Fourier phase and amplitude images from a radionuclide ventriculogram?

122. Each pixel over time is fitted to a sine wave of a particular amplitude and phase.

123. What does the amplitude image of a Fourier analysis of a radionuclide ventriculogram represent?

123. The maximum count variation for each pixel.

124. What does the phase image of a Fourier analysis of a radionuclide ventriculogram represent?

124. The time delay from the R wave to the start of the cardiac cycle for each pixel.

125. How do wall motion abnormalities appear on amplitude images of a Fourier analysis of a radionuclide ventriculogram?

125. Reduced amplitude.

126. How does dyskinesia appear on phase images of a Fourier analysis of a radionuclide ventriculogram?

126. Opposite phase to the ventricles.

127. How does Wolff–Parkinson–White syndrome appear on phase images of a Fourier analysis of a radionuclide ventriculogram?

127. Affected areas are slightly out of phase relative to the remainder of the ventricle.

128. How does a computer create a stroke volume image from a radionuclide ventriculogram?

128. It subtracts the end-systolic image from the end-diastolic image.

129. How does a computer create an ejection fraction image from a radionuclide ventriculogram?

129. It subtracts the end-systolic image from the end-diastolic image and divides the difference by the end-diastolic image.

130. What is the appearance of akinesia on an ejection fraction image?

130. Reduced intensity.

131. How does a computer create a paradox image from a radionuclide ventriculogram?

131. It subtracts the end-diastolic image from the end-systolic image.

132. What is the appearance of dyskinesia on a paradox image?

132. Increased intensity.

133. What is the hallmark of an acute myocardial infarction on a radionuclide ventriculogram?

133. Regional wall motion abnormality at the site of the infarction and a decrease in global ejection fraction.

134. True or false: Reduced ejection fraction indicates the presence of congestive heart failure.

134. False.

135. What percentage of patients with acute myocardial infarctions has abnormal ejection fractions?

135. 75%.

136. How is a radionuclide ventriculogram helpful prognostically in patients with acute myocardial infarction?

136. The lower the ejection fraction, the worse the prognosis, and a worsening ejection fraction over time indicates a worsening prognosis.

137. What type of infarction is associated with right ventricular wall motion abnormalities?

137. Inferior wall infarctions.

138. What is the hallmark of ischemia on an exercise radionuclide ventriculogram?

138. Failure of the ejection fraction to increase with stress and development of wall motion abnormalities not present at rest.

139. What are the two major limitations of the exercise radionuclide ventriculogram for assessing myocardial ischemia?

139. Difficulty of getting patients to achieve and maintain maximal stress during imaging, and nonspecificity of an abnormal response.

140. What is the sensitivity of the exercise radionuclide ventriculogram for assessing myocardial ischemia among patients who exercise adequately?

140. 85 to 94%.

141. In clinical practice, what is the specificity of the exercise radionuclide ventriculogram for assessing myocardial ischemia among patients who exercise adequately?

141. 55%.

142. What six conditions (other than coronary artery disease) can cause an abnormal response to stress on a radionuclide ventriculogram?

142. Cardiomyopathy, myocarditis, valvular heart disease, pericardial disease, drug toxicity, and prior surgery or injury.

143. How is radionuclide ventriculography useful in the follow-up of patients undergoing coronary artery bypass grafting (CABG)?

143. One can measure the ejection fraction and ventricular size at rest and stress; one can also measure stroke volume ratios to look for regurgitation.

144. What is the typical radionuclide ventriculogram appearance of patients with congestive cardiomyopathies?

144. The ventricle is dilated with global diffuse hypokinesia and a low ejection fraction.

145. Which segments can be spared in the wall motion abnormalities of a patient with congestive cardiomyopathies?

145. The basal and septal segments.

146. How is radionuclide ventriculography useful in the follow-up of patients undergoing cardiotoxic chemotherapy?

146. Patients can be followed and the drug discontinued if the ejection fraction drops more than 15%.

147. How is radionuclide ventriculography useful in the follow-up of patients with pulmonary disease?

147. The radionuclide ventriculogram can differentiate between cor pulmonale and left-sided heart disease.

148. How can left-to-right shunt be measured with a first-pass radionuclide angiogram?

148. One can detect early recirculation into the pulmonary circuit.

149. How can right-to-left shunt of congenital heart disease be measured with scintigraphy?

149. One can inject ^{99m}Tc-macroaggregated albumin (MAA) and then measure the ratio of activity over the lung and the brain.

150. How is ^{82}Rb made?

150. With a strontium/rubidium generator.

151. How is ^{13}N made?

151. In a cyclotron.

152. How is ^{18}F-fluorodeoxyglucose (FDG) made?

152. In a cyclotron.

153. In myocardial imaging, what is the positron emitter ^{82}Rb a marker of?

153. Myocardial blood flow.

154. In myocardial imaging, what is the positron emitter ^{13}N a marker of?

154. Myocardial blood flow.

155. In myocardial imaging, what is the positron emitter ^{18}F-FDG a marker of?

155. Myocardial glucose metabolism.

156. The findings of a positron emission tomography (PET) scan with ^{82}Rb or ^{13}N are most similar to a SPECT scan with what agent?

156. ^{201}Tl or ^{99m}Tc-sestamibi.

157. Under normal conditions, what percentage of the heart's energy needs is met through glucose metabolism?

157. 15%.

158. What is the preferred metabolic substrate of ischemic myocardium?

158. Glucose.

159. What is the typical ^{82}Rb/^{18}F-FDG-PET scan pattern of normal myocardium?

159. Normal blood flow (normal ^{82}Rb uptake) with normal glucose metabolism (normal ^{18}F-FDG uptake).

160. What is the typical ^{82}Rb/^{18}F-FDG-PET scan pattern of ischemic myocardium?

160. Reduced blood flow (decreased ^{82}Rb uptake) with normal glucose metabolism (normal ^{18}F-FDG uptake).

161. What is the typical ^{82}Rb/^{18}F-FDG-PET scan pattern of scarred myocardium?

161. Reduced blood flow (decreased ^{82}Rb uptake) with reduced glucose metabolism (reduced ^{18}F-FDG uptake).

162. Since thallium, sestamibi, and teboroxime are rapidly cleared from the blood and concentrated by the myocardium, their regional distribution is generally proportional to __________.

162. blood flow

163. The purpose of thallium reinjection is to increase the __________ of stress/redistribution thallium imaging in detecting viable myocardium.

164. Compared with normal myocardium, thallium washes out of ischemic myocardium at a __________ rate.

165. Compared with normal myocardium, thallium washes out of infarcted myocardium at a __________ rate.

166. Which cardiac perfusion agent washes out at a faster rate, thallium or sestamibi?

167. With which cardiac perfusion agent is redistribution the key parameter in detecting reversible ischemia, thallium or sestamibi?

168. Due to the effects of redistribution, the distribution of thallium on delayed images corresponds to the distribution of __________.

169. In exercise stress sestamibi imaging, sestamibi is injected at __________, and exercise is continued for 2 more minutes.

170. The critical organ of the body for thallium is the __________, whereas the critical organ for ^{99m}Tc-sestamibi and ^{99m}Tc-teboroxime is the __________.

171. Dipyridamole causes __________ of normal coronary vessels.

172. Dipyridamole administration results in the accumulation of __________.

173. The patient's heart rate __________ and blood pressure __________ in response to dipyridamole.

174. Dipyridamole is contraindicated in patients with asthma because of its ability to induce __________.

175. If bronchospasm or significant ischemia occurs during dipyridamole infusion, __________ should be administrated to reverse these effects.

176. SPECT thallium imaging is most sensitive in detecting disease in the distribution of the __________ artery and least sensitive in detecting disease in the distribution of the __________ artery.

177. Transient dilation of the left ventricle on an exercise stress image compared with a rest image signifies __________.

163. sensitivity

164. slower

165. equal

166. Thallium.

167. Thallium.

168. viable tissue

169. peak exercise

170. kidney; proximal colon

171. dilatation

172. adenosine

173. increases; decreases

174. bronchospasm

175. aminophylline

176. left anterior descending (LAD); circumflex

177. left ventricular dysfunction

178. Dipyridamole is administered intravenously at a dose of __________ for a total of __________ minutes.

179. In SPECT cardiac imaging, the apex is best evaluated on the __________ and __________ views.

180. In SPECT cardiac imaging, the anterior wall is best evaluated on the __________ and __________ views.

181. In SPECT cardiac imaging, the septum is best evaluated on the __________ and __________ views.

182. In SPECT cardiac imaging, the lateral wall is best evaluated on the __________ and __________ views.

183. In SPECT cardiac imaging, the inferior wall is best evaluated on the __________ and __________ views.

184. Name four nonpathologic causes of defects in SPECT cardiac imaging.

185. On a gated blood pool study, overestimating background activity results in a falsely __________ left ventricular ejection fraction.

186. Since right ventricular end-diastolic volume is greater than left ventricular end-diastolic volume, the right ventricular ejection fraction is expected to be __________ than the left ventricular ejection fraction.

187. Including a portion of the left atrium in the region of interest of the left ventricle at end-systole will result in an ejection fraction that is falsely __________.

188. On gated blood pool imaging, a photopenic halo surrounding all the chambers is indicative of a __________.

189. On gated blood pool imaging, a photopenic zone surrounding the left ventricle is suggestive of __________.

190. On gated blood pool imaging, paradoxical systolic motion of a focal region of the left ventricular wall suggests the presence of __________.

191. A gated blood pool scan or myocardial perfusion scan may show larger and more severe abnormalities in the acute phase of a myocardial infarct compared with several weeks later, due to the phenomenon of myocardial __________.

178. 0.142 mg/kg/minute; 4

179. horizontal long axis; vertical long axis

180. short axis; vertical long axis

181. short axis; horizontal long axis

182. short axis; horizontal long axis

183. short axis; vertical long axis

184. Breast or diaphragmatic attenuation, patient motion, incorrect long axis selection during processing, and a recent meal.

185. elevated

186. lower

187. decreased

188. pericardial effusion

189. left ventricular hypertrophy

190. an aneurysm

191. stunning

192. A 70-year-old man undergoing a modified Bruce treadmill stress protocol has a target heart rate of:

a) 160
b) 150
c) 128
d) 120
e) 112

192. c, 128

193. True or false: A stress study, followed in several hours by a rest study, is the protocol of choice for sestamibi myocardial perfusion imaging.

193. False.

For questions 194 through 197, match each statement with the appropriate radiopharmaceutical by choosing among the following: ^{201}Tl-chloride; ^{99m}Tc-sestamibi; ^{99m}Tc-teboroxime; both ^{201}Tl-chloride and ^{99m}Tc-sestamibi; ^{201}Tl-chloride, ^{99m}Tc-sestamibi, and ^{99m}Tc-teboroxime.

194. Most rapid washout from the heart

194. ^{99m}Tc-teboroxime

195. Redistribution from a single injection characteristic of ischemia

195. ^{201}Tl-chloride

196. A fixed defect on stress/rest imaging can represent hibernating myocardium, i.e., severe ischemia.

196. ^{201}Tl-chloride, ^{99m}Tc-sestamibi, and ^{99m}Tc-teboroxime

197. Serendipitous detection of mediastinal parathyroid adenoma possible

197. both ^{201}Tl-chloride and ^{99m}Tc-sestamibi

198. Decreased inferior wall uptake on a myocardial perfusion scan may be caused by:

a) myocardial ischemia
b) diaphragmatic attenuation
c) myocardial infarct
d) all of the above
e) none of the above

198. d, all of the above

199. Hibernating myocardium may be best confirmed on:

a) reinjection redistribution thallium images
b) rest/stress sestamibi study
c) 24-hour delayed thallium images
d) ^{18}F-FDG-PET scan
e) none of the above

199. d, ^{18}F-FDG-PET scan

200. Diminished septal activity on a stress myocardial perfusion study may be seen as an expected finding in:

a) mitral stenosis
b) Wolff–Parkinson–White syndrome
c) left bundle branch block
d) all of the above
e) none of the above

200. c, left bundle branch block

201. True or false: Intracardiac shunts may be detected on perfusion lung scan.

202. True or false: Intracardiac shunts may be detected on first-pass radionuclide angiograms.

203. True or false: Intracardiac shunts may be detected on multigated acquisition (MUGA) cardiac studies.

204. During normal aerobic metabolism, the primary substrate used by the heart for energy is __________.

205. Ischemic myocardium will show __________ uptake of ^{18}F-labeled FDG.

206. With respect to PET imaging of the heart, ^{82}Rb is used to measure myocardial __________.

207. True or false: Published reports support an approximately 95% sensitivity and specificity rate of PET myocardial perfusion studies for diagnosing coronary artery disease.

208. True or false: Ischemic myocardium, relative to normal myocardium, has increased perfusion.

209. True or false: Ischemic myocardium, relative to normal myocardium, has increased fatty acid metabolism.

210. True or false: Ischemic myocardium, relative to normal myocardium, has increased glucose metabolism.

211. True or false: Ischemic myocardium, relative to normal myocardium, has hyperkinetic wall motion.

212. True or false: The percentage of stenosis of a coronary artery is the sole determinant of the significance of coronary artery diseases.

213. What is the best and quickest way to manage adenosine side effects?

214. Which of the following are indications to terminate an exercise stress test?

a) Moderate to severe new chest pain
b) ST segment depression greater than 3 mm
c) Dizziness, near syncope
d) Claudication
e) Ventricular tachycardia, atrial fibrillation, onset of third-degree heart block
f) Significant hypotension or severe hypertension
g) All of the above

201. True.

202. True.

203. False.

204. fatty acid

205. increased

206. perfusion

207. True.

208. False.

209. False.

210. True.

211. False.

212. False.

213. Stop the infusion (half-life less than 10 seconds).

214. g, all of the above

215. What is the preferred dosing of dobutamine infusion for stress?

215. Infusion starting at 10 μg/kg/minute (3 minutes); increase by 10μg/kg/minute every 3 minutes to a maximum of 40 μg/kg/minute. Atropine can be administered as required.

216. Which drug and route are used to treat the side effects of dobutamine if persistent chest pain or arrhythmias are present?

216. Metoprolol (1–5 mg) or esmolol intravenously.

217. What is the most commonly utilized cardiac SPECT protocol in obese patients?

217. 2-day rest–stress ^{99m}Tc-sestamibi protocol.

218. True or false: A sinogram display represents multiple images stacked with minimization of the count distribution in the y-axis, and a discontinuity represents motion.

218. True.

219. What terminology should be reported for visualized perfusion defects on rest and stress images?

219. Location, size, severity, and vascular distribution. Possible artifacts should be mentioned.

220. Match each of the following to hibernation, stunning, ischemia, or infarct:

a) decreased perfusion and decreased contractility but viable; a chronic process
b) absent perfusion, contractility, and viability; fixed defect at both rest and stress
c) normal perfusion, decreased contractility; an acute process
d) mismatched perfusion defect at stress

220. a. hibernation; b. infarct; c. stunning; d. ischemia

221. What is the preferred mode of stress in patients with left bundle branch block, Wolff–Parkinson–White syndrome, or a permanent pacemaker?

221. Pharmacological vasodilator stress.

222. What is the preferred mode of stress in patients on beta (β) blockers?

222. Pharmacological vasodilator stress.

223. Absolute contraindications for adenosine stress testing include:

a) an asthmatic with ongoing wheezing and a history of intubation
b) second- or third-degree atrioventricular (AV) block without a pacemaker
c) recent intake of coffee or xanthine derivatives
d) all of the above
e) none of the above

223. d, all of the above

224. What is regadenoson, and what is its biological half-life?

224. Regadenoson is a selective A_{2A} adenosine receptor agonist with a 2- to 3-minute biological half-life.

225. How is regadenoson different from adenosine stress testing?

225. Regadenoson is administered as a fixed single bolus (0.4 mg/5 mL over 10 seconds), has a good safety and tolerability profile, and is not affected by beta (β) blockers.

226. Which of the following is the most important information obtained from the cardiac stress testing?

a) Sensitivity for coronary artery disease identification
b) Specificity for coronary artery disease identification
c) Accuracy of coronary artery disease identification
d) Prognosis and risk stratification
e) None of the above

226. d, prognosis and risk stratification

227. On which SPECT slice images are the anterior, lateral, and inferior cardiac walls better evaluated?

227. Anterior wall on horizontal short axis and vertical long axis, inferior wall on horizontal short axis and vertical long axis, and lateral wall on horizontal short axis and horizontal long axis.

228. What does segment 17 on the standardized cardiac SPECT model represent?

228. Cardiac apex.

229. What is a polar map or bull's-eye display?

229. It is a two-dimensional display of the relative perfusion in the short axis with the apex at center, the four apical segments as the first ring, the six mid-cavity segments as the second ring, and the six basal segments as the outermost ring.

230. What are the semiquantitative measures derived from the polar perfusion maps?

230. Each segment is scored on a scale of 0 to 4 (normal to absence of uptake) at both stress and rest to derive the summed stress, rest, and difference scores (SSS, SRS, and SDS).

231. A summed score can indicate the following:

a) a summed stress score (SSS) less than 4 is normal.
b) an SSS in the range 4 to 8 is mildly abnormal
c) an SSS in the range 9 to 13 is moderately abnormal
d) an SSS greater than 13 is severely abnormal
e) summed difference score (SDS) less than zero indicates an artifact
f) all of the above

231. f, all of the above

232. True or false: The diagonals are branches of the left anterior descending artery, whereas the obtuse marginals are branches of the circumflex artery.

232. True.

233. Which of the following is true regarding Agatston calcium scoring?

a) The risk of cardiac events is low with a calcium score less than 100.
b) A calcium score greater than 400 indicates high risk within the next 2 to 5 years.
c) An insignificant Hounsfield scoring results in a major calcium scoring difference.
d) It is the sum of the total calcium burden in all the coronary arteries.
e) A low and regular heart rate is essential for optimal imaging.
f) It is most useful to stratify patients, especially those in the intermediate risk group.
g) All of the above.

233. g, all of the above

234. What are the current approved cardiac PET tracers?

234. Rubidium-82 and ^{18}F-FDG.

235. What other PET tracers can be used for cardiac imaging?

235. ^{13}N ammonia and ^{15}O water for perfusion, ^{11}C tracers for fatty acid metabolism.

236. True or false: PET studies consistently demonstrate considerably higher sensitivities for coronary artery disease detection than those utilizing SPECT.

236. False.

237. True or false: PET studies demonstrate considerably higher specificities for coronary artery disease detection than those utilizing SPECT.

237. True.

238. Evaluation of coronary artery disease by PET-FDG studies in patients with diabetes mellitus is limited by their __________.

238. altered glucose metabolism

239. What is the half-life of a strontium-82/rubidium-82 generator system?

239. 25 days.

240. What is the half-life of ^{82}Ru?

240. 76 seconds.

241. What are the advantages and disadvantages of ^{82}Ru compared with conventional SPECT agents?

241. Higher image quality, lesser attenuation artifacts, shorter half-life with possibility for only pharmacological stress testing.

242. What are the different PET protocols for cardiac scintigraphy?

242. ^{82}Ru rest and stress testing, ^{82}Ru and ^{18}F-FDG testing at rest.

243. What is the most important step in the preparation of a patient for viability testing with ^{18}F-FDG?

243. Glucose loading with oral glucose and insulin administration as per protocol to promote myocardial glucose utilization.

244. True or false: A decreased perfusion on ^{82}Ru with corresponding FDG uptake represents viability and might predict successful revascularization.

244. True.

245. What are the imaging features of cardiac sarcoid on PET imaging?

245. Increased FDG activity with or without perfusion defects (especially basal left ventricular wall). Pretest preparation is essential to minimize background myocardial glucose uptake for optimal evaluation.

246. What other agents can be used for cardiac scintigraphy?

246. ^{123}I MIBG (metaiodobenzylguanidine) for cardiac adrenergic status, and ^{123}I-beta-methyl-iodophenyl pentadecanoic acid (BMIPP) for fatty acid metabolism and cardiac ischemia memory imaging.

247. 58-year-old woman with multiple risk factors (▶Fig. 6.1).

Which of the following should be included in the diagnosis of the rest/stress myocardium perfusion imaging with ^{99m}Tc-estamibi?

a) Myocardial ischemia
b) Breast attenuation
c) Myocardial infarct
d) All of the above
e) None of the above

247. d

248. What are common reasons for a false-negative rest/stress myocardial perfusion imaging?

a) Patient's failure to exercise adequately
b) Triple-vessel coronary artery disease
c) Two-vessel coronary artery disease
d) Single-vessel coronary artery disease.

248. a and b

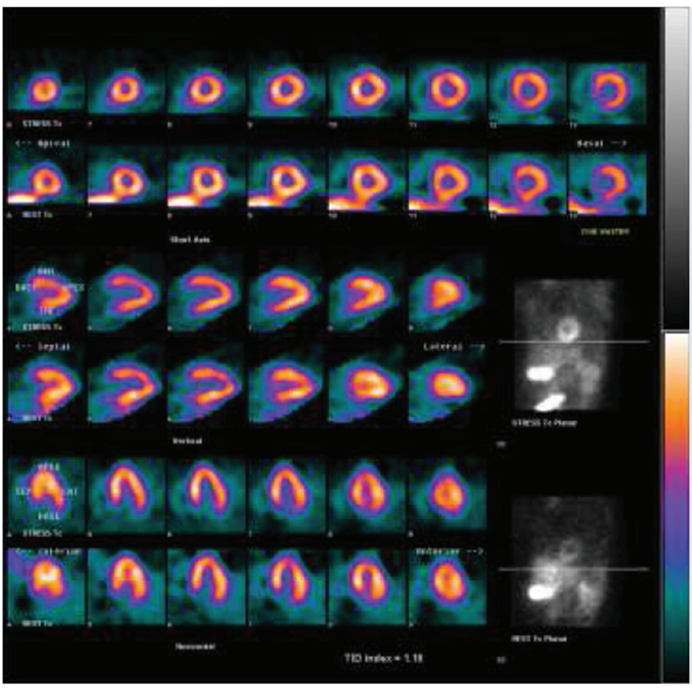

Fig. 6.1

249. Medications that interfere with cardiac stress testing includes the following:

a) beta (β) blockers
b) calcium channel blockers
c) long-acting nitrates
d) NSAID

249. a, b, and c

250. For a stress myocardial perfusion study using ^{201}Tl, how long should patients continue to exercise after the injection?

a) 1 to 2 minutes
b) 2 minutes
c) 15 seconds
d) 3 minutes

250. a

251. What percentage of maximal predicted heart rate is considered an adequate stress test?

a) 65%
b) 75%
c) 85%
d) 95%

251. c

252. 60-year-old man with shortness of breath. Dual isotope rest/stress myocardial perfusion imaging with ^{201}Tl and ^{99m}Tc-sestamibi is shown below (▶Fig. 6.2).

What of the following statement(s) is (are) true?

a) Reversible ischemia at septal wall
b) Reversible ischemia at posteroinferior wall
c) Reversible ischemia at anterior wall
d) Reversible ischemia at lateral wall

252. b, c, and d

253. In a patient with right dominant coronary artery, the inferior wall is supplied by:

a) left circumflex artery
b) right coronary artery
c) left anterior descending artery
d) left marginal artery

253. b

254. Lateral wall myocardium is supplied by:

a) left circumflex artery
b) left anterior descending artery
c) right coronary artery
d) posterior descending artery

254. a

255. The myocardium areas are supplied by the right coronary artery except

a) the inferior wall
b) the inferior septum
c) the right ventricle
d) anterior septal wall

255. d

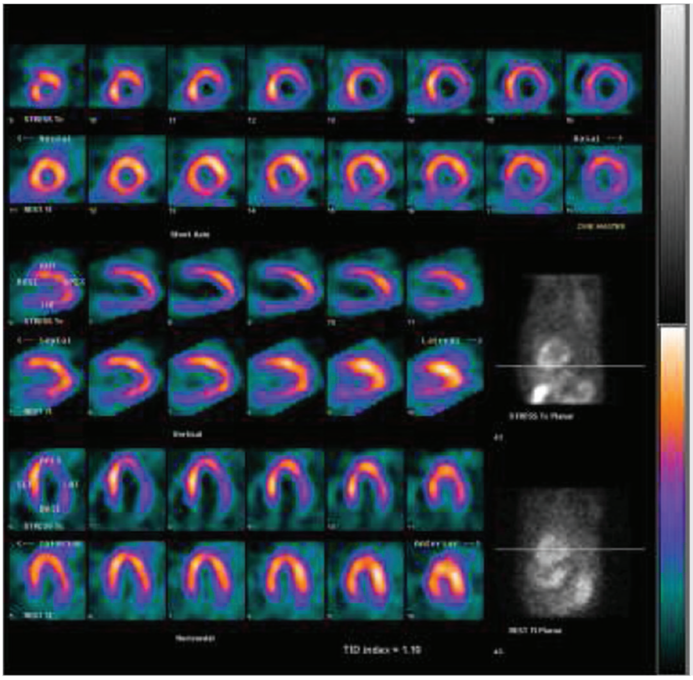

Fig. 6.2

256. How much of the intravenous ^{201}Tl dose localizes in the myocardium in a normal patient?

a) 5%
b) 10%
c) 15%
d) 20%

256. a

257. 57-year-old man with exertional dyspnea (▶Fig. 6.3)

Concerning statements below, what is (are) true of the findings on dual isotope myocardial perfusion scan, rest ^{201}Tl, and treadmill stress using ^{99m}Tc-sestamibi?

a) Left anterior descending coronary artery disease
b) Left bundle branch block
c) Mitral stenosis
d) Wolff–Parkinson–White syndrome

257. a and b

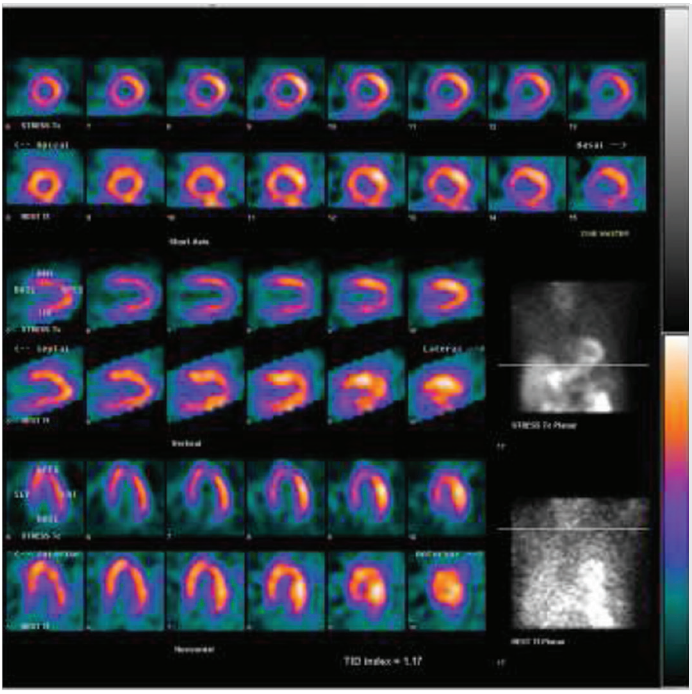

Fig. 6.3

258. Which of the following statement(s) is (are) true?

a) In a patient with left bundle branch block, a rest/treadmill stress myocardial perfusion imaging is the protocol of choice.
b) In a patient with left bundle branch block, rest/pharmacological stress myocardial perfusion imaging is the protocol of choice.
c) In a patient with left bundle branch block, septal reversible ischemia is due to left anterior descending artery stenosis.
d) In a patient with left bundle branch block, a rest/treadmill stress myocardial perfusion imaging has high false-positive rate for septal ischemia.

259. The following drug(s) is (are) approved for pharmacological stress myocardium perfusion imaging:

a) dipyridamole
b) adenosine
c) dobutamine
d) regadenoson
e) all of the above

258. b and d

259. e, all of the above

260. How much can dipyridamole, adenosine, and regadenoson increase coronary blood flow?

a) Twofold
b) Threefold
c) Four- to fivefold
d) Fivefold

260. c

261. Contraindication(s) to adenosine include:

a) second and third degree AV block
b) sinus node disease
c) bronchospasm
d) hypersensitivity to adenosine
e) all of the above

261. e, all of the above

262. 55-year-old man asymptomatic pre-op evaluation for high-risk vascular surgery. SPECT dual isotope myocardial imaging was performed (▶Fig. 6.4).

Which of the below statement(s) is (are) true?

a) The findings are consistent with myocardial infarction.
b) The findings are consistent with hibernating myocardium.
c) The findings are artifactual due to diaphragmatic attenuation.
d) The findings are consistent with stunned myocardium.

262. a, b, and c

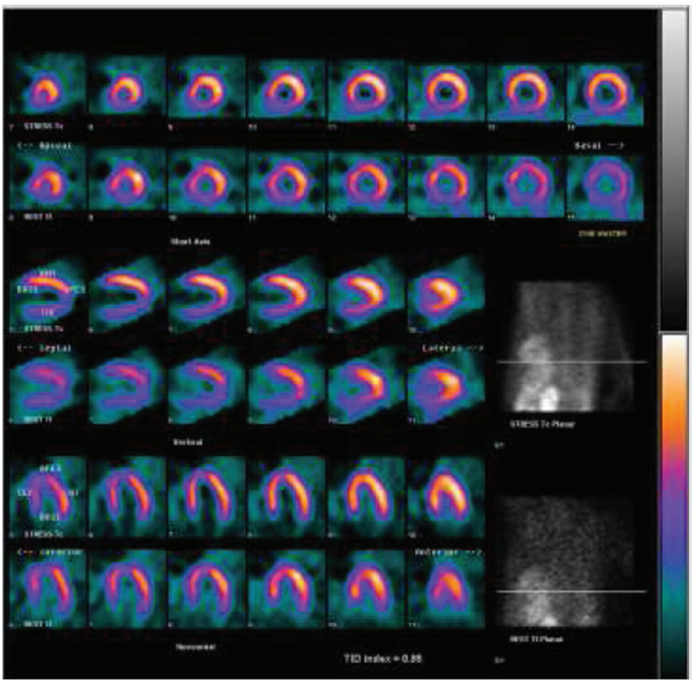

Fig. 6.4

263. How much time should patients wait before imaging after injections of ^{201}Tl for a stress myocardial perfusion study?

a) 5 minutes
b) 10 minutes
c) 20 minutes
d) 30 minutes

264. Shorter waiting time than optimum will result in:

a) cardiac creep defect
b) not enough time for myocardial uptake of injected ^{201}Tl
c) too high ^{201}Tl background
d) too much scattered photons

265. Longer waiting time than optimum will result in:

a) ^{201}Tl excessive washout from myocardium
b) the study will miss ischemia with early redistribution.
c) longer waiting time is not a problem since ^{201}Tl has no significant redistribution
d) reversible ischemia will appear as fixed defect

266. Regarding diaphragmatic attenuation artifact, which of the following is (are) true?

a) It is more common in man.
b) It is common in woman.
c) It can be corrected by acquiring the study in prone position.
d) It can be corrected by acquiring the study in left lateral decubitus position.

267. 43-year-old man with chest pain. Rest/stress ^{99m}Tc-sestamibi imaging is shown (▶Fig. 6.5).

Which of the following statement(s) is (are) true?

a) There is reversible ischemia at lateral wall.
b) There are fixed defects at apex.
c) There is fixed defect at posterior inferior wall.
d) There is transient left ventricular dilatation.
e) All of the above.

263. b

264. a

265. b

266. a, c, and d

267. e, all of the above

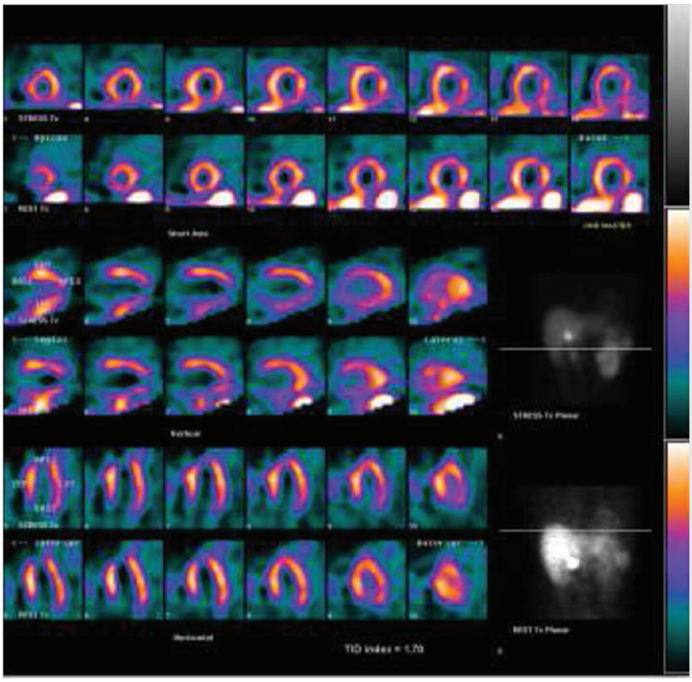

Fig. 6.5

268. Concerning ^{99m}Tc-sestamibi myocardial imaging, which of the following is (are) true?

a) Myocardial extraction fraction of ^{99m}Tc-sestamibi is approximately half that of ^{201}Tl.
b) Myocardial extraction fraction of ^{99m}Tc-sestamibi decreases with increasing flow.
c) ^{99m}Tc-sestamibi excreted by hepatobiliary and renal routes.
d) To allow for clearance of the tracer from lung and liver, imaging is delayed 30 to90 minutes after injection of ^{99m}Tc-sestamibi.
e) All of the above.

269. Which of the following statement(s) is (are) true?

a) ^{99m}Tc-sestamibi has significant redistribution.
b) First-pass radionuclide angiography and gated SPECT can be performed with ^{99m}Tc-sestamibi.
c) ^{99m}Tc-sestamibi myocardial washout is slower than ^{201}Tl.
d) Viability study can be performed with ^{99m}Tc-sestamibi.

268. e, all of the above.

269. b and c

270. Gated SPECT myocardial perfusion imaging is feasible to evaluate the following:

a) regional ventricular wall motion
b) left ventricular resting ejection fraction
c) ventricular wall thickening to differentiate scar from viable myocardium
d) help differentiating myocardial scar from attenuation artifact in a fixed defect
e) all of the above

270. e, all of the above

271. Which of the following statement(s) is (are) true?

a) Myocardium extracted ^{201}Tl from the blood through active transport mechanism by Na–K–adenosine triphosphate (ATP) pump.
b) Myocardium extracted ^{99m}Tc-sestamibi from the blood by passive diffusion.
c) ^{201}Tl is cyclotron produced.
d) ^{99m}Tc is cyclotron produced.

271. a, b, and c

272. 76-year-old woman 4 years post-CABG, asymptomatic. Rest/stress ^{99m}Tc-sestamibi myocardial imaging was performed (▶Fig. 6.6).

What is (are) the finding(s)?
a) Normal rest/stress myocardial perfusion imaging.
b) There is transient ischemic dilatation.
c) There is evidence of apical reversible ischemia.
d) There is evidence of right ventricular overload.

272. d

273. In myocardial perfusion imaging, increased uptake in right ventricle can be seen in which of the following:

a) acute right ventricular volume overload
b) acute right ventricular pressure overload
c) chronic right ventricular volume overload
d) chronic right ventricular pressure overload

273. b, c, and d

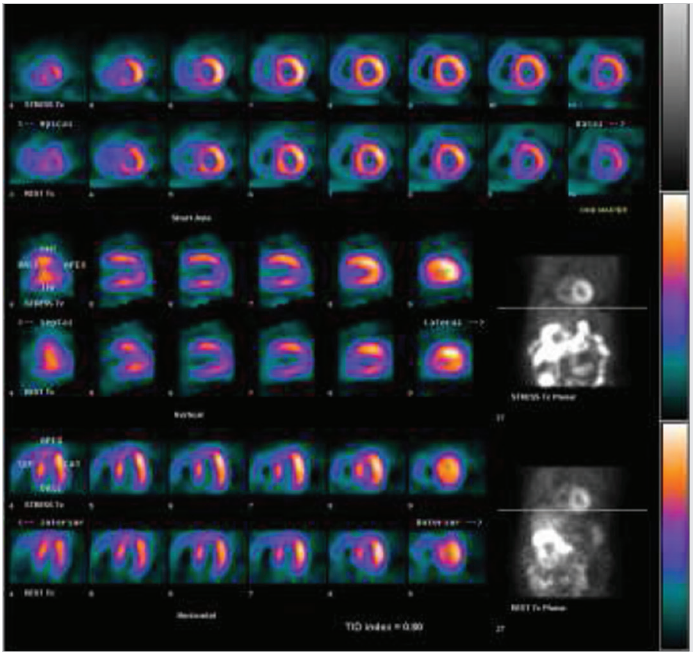

Fig. 6.6

274. In normal myocardial perfusion imaging, which of the following statement(s) is (are) true?

a) There is much less uptake in the right ventricle than that of the left.
b) More uptake in left ventricle suggests left ventricular hypertrophy.
c) Right ventricular wall thickness is approximately one-third that of the left.
d) Blood flow per gram of myocardium is less to the right ventricle.

274. a, c, and d

275. Which of the following statement(s) is (are) true?

a) Over 80% of ^{201}Tl entering coronary circulation is extracted by myocardium.
b) Approximately 50% of ^{201}Tl entering coronary circulation is extracted by myocardium.
c) ^{201}Tl extraction by the myocardium at physiologic flow rates is linearly increased in proportional to coronary blood flow.
d) At low flow rate, ^{201}Tl extraction overestimates the flow.

275. a, c, and d

276. Which of the following statement(s) is (are) true?

a) Blood flow to the myocardium supplied by normal coronary vessels will increase in response to stress.
b) Blood flow to the myocardium supplied by significantly narrowed vessels will not change or, on occasion, decrease in response to stress.
c) Blood flow to the myocardium supplied by significantly narrowed vessels will also increase in response to stress.
d) Stress will not change blood flow to myocardium if inadequate exercise was achieved.

276. a and b

277. 54-year-old with hypertension and hypercholesterolemia. The patient is on beta-blocker. Dual isotope rest/stress myocardial imaging was performed (▶Fig. 6.7).

What statement(s) below is (are) true?

a) Rest/treadmill stress myocardial perfusion imaging is the protocol of choice.
b) Rest/pharmacological stress myocardial perfusion imaging is the protocol of choice.
c) There is a large reversible ischemia at lateral wall.
d) There is transient is chemic dilatation.

277. b and c

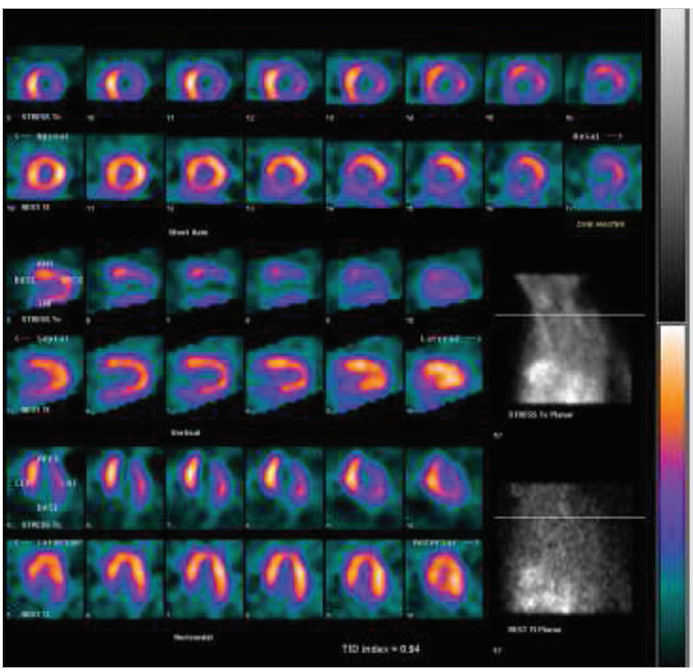

Fig. 6.7

278. There are variations in blood supply to left ventricular apex. Which of the following statement(s) is (are) true?

a) In the majority, left anterior descending artery is the only artery supplying the apex.
b) Left anterior descending artery and posterior descending artery together supply the apex.
c) Posterior descending artery alone supplies the apex.
d) Left anterior descending artery, left circumflex artery and posterior descending artery together supply the apex.

278. a, b, and c

279. Transient ischemic dilatation can be seen in which of the following?

a) Single vessel coronary artery disease
b) Multivessel coronary artery disease
c) Left ventricular dysfunction
d) Right ventricular dysfunction

279. b and c

280. Perfusion defect on stress SPECT myocardial perfusion imaging can be seen in which of the following?

a) Vasospasm
b) Myocardial bridge
c) Left bundle branch block
d) Wolff–Parkinson–White syndrome
e) All of the above

280. e, all of the above

281. Match each of the pharmaceutical stress agents (a–c) with the action to take for their severe side effects (1–3).

a) Dipyridamole
b) Dobutamine
c) Adenosine

1. Metoprolol (1–5 mg) or esmolol, IV
2. Stop infusing
3. Aminophylline (125–250 mg) IV

281. a3, b1, c2

282. 56-year-old man complains of shortness of breath. History of CABG 15 years prior. Dual isotope rest/stress myocardial perfusion was performed (▶Fig. 6.8).

Which statement(s) below is (are) true?

a) There is reversible ischemia at anterior wall.
b) There is reversible ischemia at posteroinferior wall.
c) There is reversible ischemia at septal wall.
d) There is increased lung uptake post-stress, suggesting exercise induced left ventricular dysfunction.
e) All of the above.

282. e, all of the above

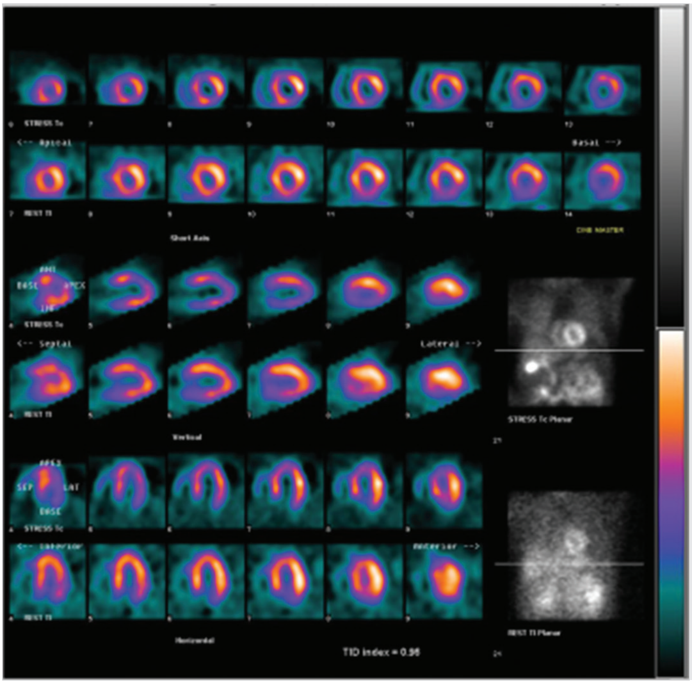

Fig. 6.8

283. Possible causes of increased lung uptake on ^{201}Tl myocardial perfusion imaging include:

a) left ventricular dysfunction
b) severe coronary artery disease
c) heavy tobacco smoking
d) mitral valve insufficiency or stenosis
e) all of the above

284. What is the upper limit of normal for the quantitative lung-to-heart ratio on ^{201}Tl myocardial perfusion imaging?

a) 0.3
b) 0.5
c) 0.7
d) 0.8

285. Anterior wall myocardium is supplied by which coronary artery (arteries)?

a) Left anterior descending
b) Left circumflex
c) Right coronary
d) None of the above

286. Anterior septal wall myocardium is supplied by which coronary artery?

a) Left anterior descending
b) Left circumflex
c) Right coronary
d) None of the above

283. e, all of the above

284. b

285. a

286. a

287. 73-year-old man with chest pain. A single isotope rest/stress myocardial perfusion imaging was done using ^{99m}Tc-sestamibi (▶ Fig. 6.9).

Which statement(s) below is (are) true?

a) There is a fixed defect sparing lateral wall.
b) These defects represent nonviable myocardium.
c) Myocardium viability can be best evaluated by ^{18}F-FDG-PET.
d) Rest/redistribution thallium scan can detect viable myocardium.

287. a, c, and d

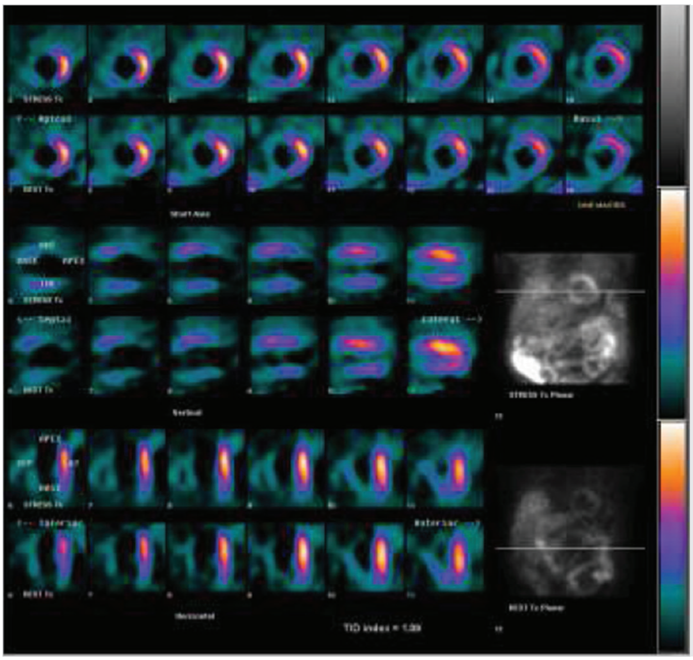

Fig. 6.9

288. Posterior wall myocardium is supplied by:

a) right coronary artery
b) left circumflex artery
c) left anterior descending artery
d) left main coronary artery

288. b

289. Inferior wall myocardium is supplied by:

a) right coronary artery
b) left circumflex artery
c) left anterior descending artery
d) left main coronary artery

289. a

290. In a setting of multiple vessel disease and balanced ischemia resulting in relatively normal perfusion images, what other findings might be abnormal?

a) Transient ischemia dilatation.
b) Decreased ejection fraction.
c) Increased lung uptake might be seen in cases of thallium stress.
d) Global hypokinesis on MUGA.
e) All of the above.

290. e, all of the above

291. Noncoronary cardiac disease entities that cause defects on SPECT cardiac imaging include which of the following:

a) aortic stenosis
b) aortic insufficiency
c) dilated cardiomyopathy
d) hypertensive cardiomyopathy
e) all of the above

291. e, all of the above

292. 83-year-old man with shortness of breath. Suspicious for congestive heart failure. A MUGA was performed (▶Fig. 6.10a, b).

Which statement(s) below is (are) true?

a) There is dilatation of left atrium and left ventricle.
b) There is global hypokinesis with low ejection fraction.
c) Reduced ejection fraction indicates the presence of congestive heart failure.
d) Normal range for left ventricular ejection fraction is 55 to 75%.

292. a, b, and d

293. Which of the following statement(s) is (are) true?

a) The radiopharmaceutical of choice for MUGA is ^{99m}Tc-labeled red blood cells (RBCs).
b) ^{99m}Tc bind to beta chain of hemoglobin.
c) Labeling of RBCs can be done in vivo, modified in vivo and in vitro.
d) The best labelling efficiency is achieved by in vivo technique.

293. a, b, and c

294. There are many drugs that interfere with RBCs labeling. Among the drugs below choose the one(s) that does (do):

a) aspirin
b) heparin
c) iodinated contrast media
d) doxorubicin

294. b, c, and d

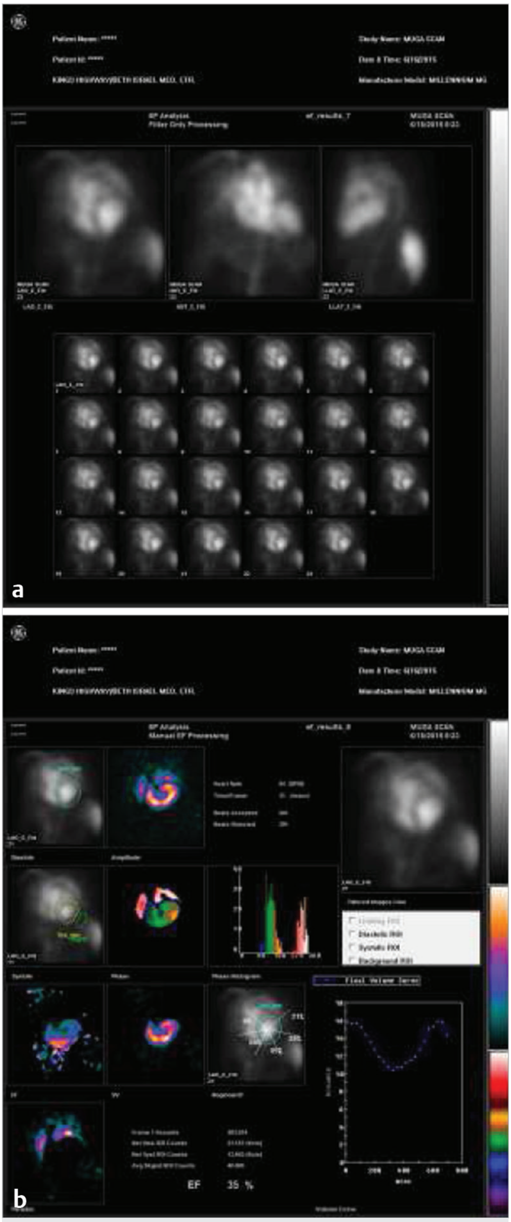

Fig. 6.10

295. The earliest indicator of congestive heart failure is a drop in:

a) left ventricular ejection fraction
b) left ventricular stroke volume
c) cardiac output
d) pulse pressure

295. a

296. The most common indication for performing resting MUGA cardiac studies is:

a) cardiac injury following catheterization
b) Adriamycin toxicity
c) detection of coronary artery disease
d) detection of valvular heart disease

296. b

297. (▶Fig. 6.11)

Imaging findings are most consistent with the below diagnosis:
a) left ventricular hypertrophy
b) right ventricular hypertrophy
c) **D**-shaped left ventricle
d) transient ischemic dilatation

297. b, c

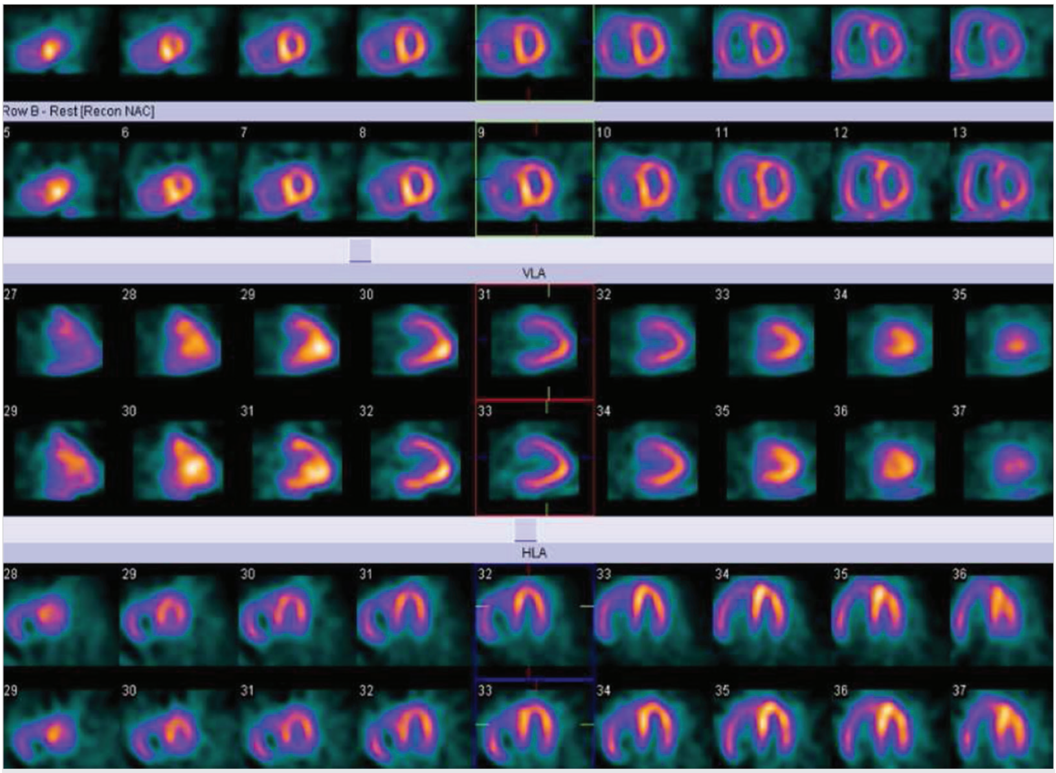

Fig. 6.11

7 Central Nervous System

Questions

1. What is the physiologic principle behind blood–brain barrier imaging?
2. What three tracers are used for blood–brain barrier imaging?
3. What is the main disadvantage of ^{99m}Tc-pertechnetate for blood–brain barrier imaging?
4. Why does ^{99m}Tc-glucoheptonate have better uptake in brain tumors than other blood–brain barrier imaging agents?
5. How do corticosteroids affect blood–brain barrier imaging?
6. How is blood–brain barrier imaging performed?
7. On blood–brain barrier imaging, how much uptake is present in the healthy brain?
8. What structures are seen only on blood–brain barrier imaging?
9. What are the findings of subdural hematoma on blood–brain barrier imaging?
10. What are the findings of a ventriculitis on blood–brain barrier imaging?
11. What are the findings of an abscess on blood–brain barrier imaging?
12. What are the findings of herpes encephalitis on blood–brain barrier imaging?

Answers

1. Tracers stay within the blood pool and diffuse into the brain only when the blood–brain barrier is disrupted.
2. ^{99m}Tc-pertechnetate, ^{99m}Tc-DTPA, and ^{99m}Tc-glucoheptonate.
3. It localizes physiologically in the choroid plexus.
4. As a glucose analog, it may serve as a substrate for tumor metabolism.
5. They may diminish uptake, because corticosteroids decrease the permeability of the blood–brain barrier.
6. Blood flow images are obtained every 1 to 3 seconds for 1 minute, then 750K count immediate static images are taken in multiple views, and then, 1.5 to 2 hours later, 750K count delayed static images are obtained in multiple views.
7. None.
8. The scalp and venous sinuses.
9. Peripherally reduced flow on dynamic images, with increased uptake on delayed images.
10. Bilaterally increased uptake in the region of the lateral ventricles.
11. A focal area of increased uptake on delayed imaging, with a cold center developing as the abscess progresses.
12. Increased flow and uptake in the affected temporal lobe.

13. What is the characteristic finding of an infarct on the angiogram portion of a blood–brain barrier scan?

13. Reduced arterial perfusion with increased venous perfusion; these symptoms are known as the "flip-flop" phenomenon. This is due to delayed arrival of the radiotracer at the site of an infarct via collateral vessels coupled with delayed washout from the area.

14. How long after an infarct is the "flip-flop" perfusion first seen on blood–brain barrier imaging?

14. In the first few days.

15. What is "luxury perfusion"?

15. Increased blood flow to an infarction due to uncoupling of blood flow from metabolism, typically seen about 5 days after the infarct.

16. What is the best tracer to use to diagnose venous sinus thrombosis?

16. ^{99m}Tc-RBCs.

17. What is the best tracer to use to diagnose venous sinus thrombosis and what is the typical finding of venous sinus thrombosis?

17. ^{99m}Tc-RBCs; abrupt termination of the midportion of sinus.

18. What are the findings of an arteriovenous malformation on brain imaging with ^{99m}Tc-RBCs?

18. Intense uptake on delayed images.

19. What is the advantage of radionuclide angiography over the electroencephalogram (EEG) in confirming brain death?

19. Radionuclide angiography remains accurate in the face of hypothermia and drug intoxication.

20. What are the scintigraphic criteria for brain death on a radionuclide angiogram?

20. Presence of a good carotid bolus without intracranial arterial flow.

21. What is the significance of faint visualization of the venous sagittal sinus or the transverse sinus on radionuclide angiography to confirm brain death?

21. It may be seen in 10 to 20% of patients with brain death and does not preclude the diagnosis of brain death, so long as there is no intracranial arterial flow.

22. What are the common features of tracers for imaging regional cerebral perfusion?

22. They are small, neutral lipophilic molecules; they rapidly diffuse across the blood–brain barrier; they have a high brain extraction fraction; and they remained fixed in the brain.

23. Name available tracers for cerebral perfusion scintigraphy.

23. ^{99m}Tc–hexamethyl propylene amine oxime (HMPAO), and ^{99m}Tc–ethylcysteine dimer (ECD).

24. Thallium 201 uptake in central nervous system (CNS) tumors is dependent on which of the following:

a) disruption of the blood–brain barrier
b) ATPase activity of the sodium-potassium pump
c) active transmembrane transport via the K^+/glucose co-transport system in viable tumor cells
d) none of the above

24. a, b, and c

25. In regard to thallium 201 brain imaging, which of the following is true?

a) Thallium will not cross an intact blood–brain barrier.
b) Thallium dose not accumulate in benign tumors.
c) Thallium accumulation is dependent on tumor grade.
d) Thallium accumulation is minimal or absent at sites of radiation necrosis.

25. a, c, and d

26. What is the main difference between ^{123}I-IMP and ^{99m}Tc-HMPAO (hexamethyl propylene amine oxime) in brain uptake distribution?

26. ^{123}I-IMP demonstrates redistribution that is independent of brain–blood flow.

27. Which of the following statements regarding thallium 201 brain imaging is correct?

a) There is normally little or no thallium uptake in the white matter.
b) Detectability of brain lesions depends on lesion size and location.
c) Steroid administration affects the thallium uptake
d) Delayed thallium imaging may be helpful to differentiate inflammatory lesions (early washout) from neoplastic lesions (retain the activity).

27. a, b, and d

28. What percentage of a dose of ^{99m}Tc-HMPAO localizes in the normal brain?

28. 3.5 to 7%.

29. What is the ratio of gray-to-white matter uptake with ^{99m}Tc-HMPAO?

29. 2.5:1.

30. Which of the following statements are correct?

a) In HIV patients, the incidence of CNS lymphoma is higher as compared to toxoplasmosis.
b) Lymphomas will generally be thallium and gallium scan positive.
c) Toxoplasmosis infection is thallium negative, but gallium positive.
d) On thallium brain imaging, the lesion to nonlesion uptake ratio is greater than 2.5:1 in CNS lymphoma.

30. b, c, and d

31. How long after injection of ^{99m}Tc-HMPAO does peak brain uptake occur?

31. 2 minutes.

32. What percentage of a dose of ^{99m}Tc-ECD (ethylcysteine dimer) localizes in the healthy brain?

32. 6 to 7%.

33. How long after injection of ^{99m}Tc-ECD does peak brain uptake occur?

33. 2 minutes.

34. How do ^{99m}Tc-HMPAO and ^{99m}Tc-ECD differ in terms of blood pool clearance?

34. Blood pool clearance is faster with ^{99m}Tc-ECD.

35. How do the circumstances of injection affect cerebral perfusion imaging?

35. Stimulation (e.g., visual or auditory) during the injection can cause areas of increased uptake in the site stimulated.

36. What type of image acquisition is required for cerebral perfusion imaging?

36. SPECT acquisition.

37. What is the normal pattern of perfusion tracer distribution in an adult brain?

37. The normal adult brain shows bilateral symmetric tracer distribution. The visual cortex of the occipital lobes and the cerebellum demonstrate the most intense activity. Less intense symmetric uptake is present in the basal ganglia and thalami.

38. What is the normal pattern of perfusion tracer distribution in the brain of a newborn?

38. The blood flow to the frontal and temporoparietal regions of the brain is slightly decreased. By 2 years of age, the cerebral pattern of perfusion should be similar to normal adult brain.

39. How does blood flow change in the occipital lobes when the eyes are open versus when they are closed?

39. Blood flow increases by approximately 30%.

40. How does an ictal seizure focus affect regional cerebral blood flow (rCBF)?

40. It causes an increase in blood flow.

41. What practical methods are available to quantify absolute rCBF with single-photon emission computed tomography (SPECT)?

41. None.

42. What methods are available to quantify absolute rCBF with radionuclide imaging?

42. PET imaging with ^{15}O water, or ^{15}C carbon dioxide, or ^{133}Xe imaging with a multiprobe detector.

43. How does an interictal seizure focus affect rCBF?

43. It causes a decrease in blood flow.

44. What is the critical organ and what is its radiation dose for ^{99}Tc-HMPAO?

44. The lacrimal glands, with 5.2 rad (52 mGy)/20 mCi (740 MBq).

45. How long after infarction will decreased blood flow be seen on a cerebral perfusion scan?

45. Immediately.

46. In patients with cerebral infarcts, why are defects on cerebral perfusion images often larger than on computed tomography (CT) scans?

46. The area of infarction is surrounded by an ischemic area of decreased blood flow.

47. What is the cause of crossed cerebellar diaschisis?

47. Decreased activity in the cerebellar hemisphere contralateral to supratentorial infarction or a lesion due to interruption of the corticopontocerebellar pathway.

48. Which two factors decrease the sensitivity of cerebral perfusion imaging for infarctions?

48. Luxury perfusion and difficulty detecting lacunar infarcts.

49. True or false: 180-degree acquisitions on ^{99}Tc-HMPAO studies are diagnostically comparable to 360-degree acquisitions.

49. False.

50. What is the typical scintigraphic pattern of Alzheimer's disease on cerebral perfusion imaging?

50. Bilateral posterior temporal and parietal hypoperfusion.

51. What is the typical scintigraphic pattern of Pick's disease on cerebral perfusion imaging?

51. Bilateral frontal hypoperfusion.

52. What is the typical scintigraphic pattern of multi-infarct dementia on cerebral perfusion imaging?

52. Multiple asymmetric perfusion defects involving both the cortex and deep structures.

53. What is the positive predictive value of brain perfusion scintigraphy for Alzheimer's disease?

53. Approximately 80%.

54. What is the typical scintigraphic pattern of depression on cerebral perfusion imaging?

54. Normal perfusion.

55. What is the typical scintigraphic pattern of metabolic brain dysfunction on cerebral perfusion imaging?

55. Normal perfusion.

56. What is the typical scintigraphic pattern of Huntington's chorea on cerebral perfusion imaging?

56. Reduced perfusion of the caudate nucleus.

57. What is the typical scintigraphic pattern of AIDS dementia on cerebral perfusion imaging?

57. Multifocal or patchy cortical and subcortical regions of hypoperfusion.

58. What is the typical scintigraphic pattern of an interictal seizure focus on cerebral perfusion imaging?

58. Hypoperfusion.

59. What is the typical scintigraphic pattern of an ictal seizure focus on cerebral perfusion imaging?

59. Hyperperfusion.

60. What is the sensitivity of brain perfusion SPECT for the detection of interictal seizure foci?

60. Approximately 65 to 75%.

61. What is the relative sensitivity of brain perfusion SPECT for the detection of the ictal versus interictal seizure foci?

61. The sensitivity is greater for ictal foci.

62. How is brain perfusion SPECT useful in conjunction with the Wada test?

62. Brain perfusion SPECT can demonstrate the exact territory perfused by the pentobarbital.

63. How is ^{201}Tl imaging useful for the assessment of brain tumors?

63. The degree of the 201Tl uptake is proportional to the malignant grade of the tumor, and uptake in the brain distinguishes recurrent brain tumor from radiation necrosis.

64. How is ^{201}Tl imaging useful for the assessment of AIDS patients with intracerebral mass lesions?

64. The ^{201}Tl uptake indicates the presence of brain tumors such as lymphoma; absence of ^{201}Tl uptake indicates the presence of infection, such as toxoplasmosis.

65. Which tracer is currently used for radionuclide cisternography?

65. Intrathecal ^{111}In-DTPA.

66. What is the critical organ, and its radiation dose, for intrathecal Indium 111 diethylenetriamine pentaacetic acid (^{111}In-DTPA)?

66. The surface of the spinal cord, with 5 rad (50 mGy)/0.5 mCi (18.5MBq).

67. How can radionuclide cisternography distinguish normal-pressure hydrocephalus from cerebral atrophy?

67. Cisternography will show prolonged ventricular uptake in normal-pressure hydrocephalus.

68. How is radionuclide cisternography used for the detection of cerebrospinal fluid (CSF) leaks?

68. Imaging to visualize leaked radioactivity; pledgets placed in the nasal cavity and counted for the leaked radioactivity.

69. True or false: In the initial stage of cerebral ischemia, rCBF increases.

69. False.

70. True or false: In the initial stage of cerebral ischemia, regional oxygen extraction fraction (rOEF) increases.

70. False.

71. True or false: With cerebral infarction, rOEF increases.

71. False.

72. True or false: With cerebral infarction, the cerebral metabolic rate for glucose (CMR_{glc}) increases.

72. False.

73. True or false: In the subacute phase of cerebral infarction, local cerebral blood flow (lCBF) increases.

73. True.

74. The phenomenon of metabolic changes in the brain distal to the location of ischemic injury is called __________.

74. diaschisis

75. In Alzheimer's disease, symmetric decreases in perfusion and metabolism occur in the:

a) frontal lobes
b) brain stem
c) occipital lobes
d) temporal parietal lobes

75. d, temporal parietal lobe

76. True or false: In Parkinson's disease, positron emission tomography (PET) perfusion studies demonstrate decreased perfusion to the basal ganglia contralateral to the affected limb.

76. False.

77. Perfusion and metabolism in seizure foci __________ during the ictal phase and __________ during the interictal phase.

77. increase; decrease

78. True or false: In Parkinson's disease, there is increased ^{18}F-fluorodopa uptake by the striatum (caudate nucleus and putamen).

78. False.

79. True or false: Concerning brain tumors, an advantage of fluorodeoxyglucose (FDG)-PET is that it can image metabolically active cells, unlike gadolinium-enhanced magnetic resonance imaging (MRI) and contrast-enhanced CT that image areas where there is blood–brain barrier breakdown.

80. Under usual conditions, the primary substrate for brain metabolism is:

a) glucose
b) fatty acids
c) proteins
d) all the above
e) none of the above

For questions 81 through 86, match the cause of dementia with the one pattern of cerebral perfusion and/or glucose metabolism with which it is most often associated:

a) decreased glucose metabolism and perfusion in caudate nucleus and putamen
b) hypoperfusion and metabolism in temporoparietal regions
c) severe depression of lenticular nuclei glucose metabolism
d) generalized cortical hypoperfusion and hypometabolism favoring prefrontal regions
e) patchy, multifocal cortical and subcortical hypoperfusion and hypometabolism
f) scattered foci of decreased cortical perfusion and metabolism
g) decreased perfusion and metabolism uniform across all basal ganglia

81. Pick's disease

82. Multi-infarct dementia

83. Alzheimer's disease

84. Huntington's disease

85. Wilson's disease

86. AIDS dementia

79. True.

80. a, glucose

81. d, generalized cortical hypoperfusion and hypometabolism favoring prefrontal regions

82. f, scattered foci of decreased cortical perfusion and metabolism

83. b, hypoperfusion and metabolism in temporoparietal regions

84. a, decreased glucose metabolism and perfusion in caudate nucleus and putamen

85. c, severe depression of lenticular nuclei glucose metabolism

86. e, patchy, multifocal cortical and subcortical hypoperfusion and hypometabolism

87. True or false: Gadolinium-enhanced MRI and ^{18}F-FDG-PET imaging are equally capable of distinguishing between recurrent brain tumor and radiation necrosis.

87. False.

88. True or false: All malignant brain tumors demonstrate hypermetabolism of ^{18}F-FDG.

88. False.

89. True or false: ^{11}C-labeled amino acid analogs may demonstrate hypermetabolism in brain neoplasms that do not show hypermetabolism of ^{18}F-FDG.

89. True.

90. True or false: In differentiation between infectious and neoplastic brain lesions, the presence of hypermetabolism is not useful.

90. False.

91. Which of the following components of a two-headed gamma camera system is not necessary for coincidence detection?

a) Crystals
b) Photomultiplier tubes (PMTs)
c) Collimators
d) Computer

91. c, collimators

92. True or false: With respect to coincidence detection, in comparison to SPECT imaging, increasing crystal thickness will improve the sensitivity of the camera.

92. True.

93. True or false: Positron emitters (e.g., ^{18}F-FDG) can be imaged only with PET scanners or two-headed gamma cameras.

93. False.

94. Bismuth germinate (BGO) crystals are preferred for PET imaging over sodium iodide (NaI) because they:

a) have better energy resolution
b) are more efficient scintillators
c) are more sensitive to 511 keV
d) all the above
e) none of the above

94. c, are more sensitive to 511 keV

95. Which of the following SPECT imaging agents does not measure perfusion?

a) ^{82}RbCl
b) ^{15}O-H_2O
c) ^{13}N-NH_3
d) ^{18}F-FDG
e) In fact, all the above do

95. e, all of the above measure perfusion

96. Concerning PET versus SPECT imaging, which of the following statements is false?

a) PET is inferior for quantification.
b) PET imaging agents generally have short half-lives.
c) PET is more sensitive.
d) PET has better spatial resolution.
e) Attenuation correction is possible with PET.

97. True or false: The positron emitter ^{15}O can be administered via intravenous injection or inhalation.

98. True or false: SPECT radiopharmaceuticals are cheaper to produce because most do not require an on-site cyclotron.

99. True or false: Attenuation correction is more accurate for SPECT because only one photon is attenuated versus two for positron images.

100. True or false: PET has more uniform resolution and higher sensitivity that SPECT.

101. True or false: Many useful single-photon emitters have stable biologic counterparts that can be used to label compounds of biologic interest.

102. True or false: PET studies of the brain have been used for in vivo quantification of glucose utilization.

103. True or false: PET studies of the brain have been used for in vivo quantification of blood flow.

104. True or false: PET studies of the brain have been used for in vivo quantification of blood volume.

105. True or false: PET studies of the brain have been used for in vivo quantification of CSF volume.

106. True or false: PET studies of the brain have been used for in vivo quantification of CSF production rates.

107. True or false: PET studies of the brain have been used for in vivo quantification of blood–brain barrier integrity.

108. True or false: PET studies of the brain have been used for in vivo quantification of receptor sites.

109. The brain almost exclusively uses __________ as its substrate for energy.

96. a, PET is inferior for quantification.

97. True.

98. True.

99. False.

100. True.

101. False.

102. True.

103. True.

104. True.

105. False.

106. False.

107. True.

108. True.

109. glucose

110.	True or false: ^{18}F-FDG freely crosses the blood–brain barrier via the same carrier-mediated transport system as glucose.	**110.**	True.
111.	With respect to PET imaging of the brain, the term "CMR_{glc}" refers to __________.	**111.**	cerebral metabolic rate of glucose
112.	True or false: The normal global CMR level, based on studies in normal healthy volunteers, is approximately 30 µmol glucose/min/100 g brain.	**112.**	True.
113.	True or false: Local cerebral metabolic rates of glucose (in specific areas of the brain such as the thalamus, basal ganglia, or lobes) can be determined through PET studies.	**113.**	True.
114.	The major limitation to determining local cerebral metabolic rates of glucose by PET studies is __________.	**114.**	the size of the area of interest
115.	True or false: Approximately 20 to 30 mCi (740–1,110 MBq) of ^{18}F-FDG should be administered for a brain study.	**115.**	False.
116.	True or false: A routine FDG study can be performed 5 minutes after radiopharmaceutical administration.	**116.**	False.
117.	True or false: External stimuli can increase regional glucose metabolism within particular areas of the brain.	**117.**	True.
118.	Hypometabolism in the thalamus ipsilateral to an infarcted basal ganglion demonstrates the phenomenon of __________.	**118.**	diaschisis
119.	The phenomenon of high blood flow in areas of the brain involved by nonacute infarction is termed __________.	**119.**	luxury perfusion
120.	Because areas of the brain involved by nonacute infarction demonstrate relative hyperperfusion compared with their normal oxygen requirements, the oxygen extraction fraction (OEF) in these regions __________.	**120.**	decreases
121.	True or false: PET studies have shown that in the immediate postinfarct period some patients demonstrate increased OEF in the involved region of the brain. This indicates that in such patients, flow would be adequate to meet local metabolic demands.	**121.**	False.
122.	Patients with Alzheimer's disease demonstrate the greatest decrease in metabolism in the __________ cortex.	**122.**	parietal

123.	True or false: Global glucose metabolism (compared with normal) decreases to a greater degree in multi-infarct dementia than in Alzheimer's dementia.	**123.**	False.
124.	True or false: Lacunar infarcts are much more easily identified with ^{18}F-FDG-PET studies than by CT.	**124.**	False.
125.	True or false: CT can reliably distinguish Alzheimer's disease from multi-infarct dementia.	**125.**	False.
126.	True or false: In Huntington's disease, changes in the caudate nuclei can be observed on PET earlier than with CT.	**126.**	True.
127.	Cerebral glucose metabolism and cerebral blood flow are __________ during seizures.	**127.**	increased
128.	Cerebral glucose metabolism and cerebral blood flow are __________ in the postinfarct period.	**128.**	decreased
129.	True or false: ^{18}F choline allows differentiation between benign lesions, high-grade gliomas, and metastatic lesions	**129.**	True.
130.	True or false: The brain metastases show higher fluorocholine uptake than high-grade gliomas.	**130.**	True.
131.	True or false: In the United States, Medicare reimbursement is currently available for PET/CT studies used to identify seizure foci in patients with new-onset epilepsy and no other workups.	**131.**	False.
132.	True or false: In the United States, Medicare reimbursement is currently available for PET/CT studies used to distinguish residual brain tumor from fibrotic tissue.	**132.**	True.
133.	True or false: In the United States, Medicare reimbursement is currently available for PET/CT studies used to identify seizure foci in patients refractory to drug therapy.	**133.**	True.
134.	Planar brain scintigraphy has a resolution of approximately __________ at the brain's surface. Multiple detector SPECT cameras are able to distinguish lesions as small as __________, while PET can differentiate structures as small as __________ in size.	**134.**	1 cm; 8 mm; 5 mm
135.	^{99m}Tc-pertechnetate, ^{99m}Tc-glucoheptonate, and ^{99m}Tc-DTPA are all examples of __________ markers.	**135.**	extracellular fluid

136.	Extracellular fluid markers are normally excluded from cerebral tissue by the __________.	**136.**	blood–brain barrier
137.	Pertechnetate is loosely bound to __________, and it is slowly cleared from the bloodstream.	**137.**	albumin
138.	The uptake of radiotracer by the choroid plexus makes __________ a less desirable radiopharmaceutical for dynamic brain flow imaging than Tc-DTPA or Tc-labeled RBCs (red blood cells).	**138.**	^{99m}Tc-pertechnetate
139.	If ^{99m}Tc-pertechnetate is to be used in brain flow scintigraphy, the patient should be given __________ to block uptake by the choroid plexus.	**139.**	potassium perchlorate
140.	The typical adult dose of potassium perchlorate is __________. Children between the ages of 2 and 12 should receive __________, while infants under the age of 2 should be given __________.	**140.**	200 mg; 100 mg; 50 mg
141.	__________ is a neoplasm that accumulates excessive amounts of pertechnetate.	**141.**	Choroid plexus papilloma
142.	Tracers used to measure cerebral blood flow must have a high __________ extraction fraction.	**142.**	first-pass
143.	During evaluation for brain death, a tourniquet may be placed around the patient's head to exclude activity from the __________ circulation.	**143.**	external carotid
144.	EEG tracings are unreliable for determining brain death in patients with __________ or __________.	**144.**	barbiturate poisoning; hypothermia
145.	Brain flow scintigraphy as a test for brain death is unaffected by __________ or __________.	**145.**	barbiturate intoxication; body temperature
146.	The "hot nose" sign may be seen in brain death and is due to increased flow in the __________ circulation.	**146.**	external carotid
147.	True or false: Normal brain metabolism of FDG may obscure small brain metastases.	**147.**	True.
148.	Areas of breakdown in the blood–brain barrier appear as foci of __________ uptake when extracellular fluid markers are used.	**148.**	increased
149.	^{99m}Tc-HMPAO and ^{123}I-IMP are lipophilic tracers that differ from extracellular fluid markers due to their ability to cross the __________.	**149.**	blood–brain barrier
150.	^{99m}Tc-HMPAO and ^{123}I-IMP are taken up by the brain in proportion to __________.	**150.**	regional blood flow

151.	^{99m}Tc-HMPAO binds intracellularly and reaches equilibrium in __________.	**151.**	5 minutes
152.	^{123}I-IMP reaches equilibrium in __________ but redistributes over several hours.	**152.**	20 minutes
153.	True or false: Persistent ventricular filling on a radionuclide cisternogram is diagnostic of communicating hydrocephalus.	**153.**	True.
154.	The major advantage of ^{99m}Tc-HMPAO over ^{123}I-IMP is its significantly better __________.	**154.**	resolution
155.	In the determination of brain death, one of the advantages of ^{99m}Tc-HMPAO and ^{123}I-IMP is their ability to evaluate the __________.	**155.**	posterior fossa
156.	^{123}I-IMP and thallium show evidence of __________ in the brain and heart, respectively.	**156.**	redistribution
157.	The __________ sign has been described in stroke patients and is due to slower collateral circulation to infarct parenchyma.	**157.**	"flip-flop"
158.	In regard to brain death evaluation, which of the following is true? (Choose all that apply.) a) Lack of blood flow to the brain in the presence of carotid bolus indicates brain death. b) Lack of venous sinus activity is consistent with no venous return. c) Scalp activity excludes brain death. d) "Hot nose" sign excludes brain death.	**158.**	a, b
159.	Epileptic seizure foci typically show increased uptake of ^{99m}Tc-HMPAO and ^{123}I-IMP during the __________ phase and decreased uptake during the __________ period.	**159.**	ictal; interictal
160.	In a normal ^{99m}Tc-HMPAO study, the greatest uptake of activity is seen in __________ matter structures.	**160.**	gray
161.	A __________ collimator tilted at 30 degrees allows a SPECT detector to remain close to the patient's head and clear the shoulders.	**161.**	slant hole
162.	A normal SPECT study cannot exclude multi-infarct dementia, since __________ are often too small to be detected.	**162.**	lacunar infarcts
163.	When compared with SPECT, CT and MRI tend to __________ the extent of cerebral infarction.	**163.**	underestimate

164. Alzheimer's disease is characterized by symmetric perfusion deficits in the __________ regions on brain SPECT imaging.

164. posterior temporal and parietal

165. Patients with Huntington's disease show __________ striatal metabolism.

165. decreased

166. Which of the following is incorrect regarding FDG-PET/CT imaging?

a) FDG-PET is superior to perfusion SPECT to diagnose Alzheimer's dementia.
b) FDG-PET provides an indirect measure of brain perfusion.
c) FDG-PET can differentiate brain tumor from abscess.
d) FDG-PET imaging generates greater spatial resolution than SPECT imaging.

166. c

167. ^{15}O is a __________ emitter with a half-life of 2 minutes.

167. positron

168. ^{13}N is a PET agent with a half-life of __________.

168. 10 minutes

169. __________ is cyclotron produced and has a half-life of 20 minutes.

169. ^{11}C

170. Tomographic imaging can be performed when PET tracers are labeled with __________.

170. ^{18}F

171. __________ is used to measure local cerebral metabolic rate.

171. ^{18}F-FDG

172. Following transport from the vascular space into brain parenchyma, ^{18}FDG is phosphorylated by __________ FDG-6-PO_4.

172. hexokinase

173. Diminished temporoparietal uptake of ^{18}FDG is typically seen in __________.

173. Alzheimer's disease

174. SPECT and PET studies have both shown decreased rCBF in the __________ lobes of schizophrenics.

174. frontal

175. In patients with astrocytomas, FDG-PET studies have shown a linear correlation between glucose metabolic rate and __________.

175. histologic grade

176. Cerebral blood __________ can be measured using ^{11}C- or ^{15}O-labeled carbon monoxide.

176. volume

177. Radiolabeled benzamide, lisuride, and spiperone derivatives attach to __________ receptors in the brain.

177. dopamine D2

178. Labeled benzapine derivatives attach to __________ receptors in patients with psychotic and movement disorders.

178. dopamine D1

179.	^{11}C-labeled __________ is a high-affinity opiate antagonist that binds to mu (μ) receptors in the CNS.	**179.**	carfentanil
180.	__________ is the radiopharmaceutical most frequently used to assess the patency of the ventriculoperitoneal shunt.	**180.**	^{99}Tc-DTPA
181.	Due to its relatively long half-life, __________ is the preferred radiotracer for nuclear cisternography.	**181.**	^{111}In-DTPA
182.	Radiotracer normally clears from the basal cisterns and ascends over the convexities by __________ hours postinjection.	**182.**	24
183.	At 48 hours, all activity should be at the vertex for resorption into the __________.	**183.**	arachnoid granulations
184.	In nuclear cisternography, radiotracer normally does not enter __________.	**184.**	the lateral ventricles, nasal cavity, or internal auditory canal
185.	In __________ hydrocephalus, radiotracer preferentially enters the lateral ventricles.	**185.**	normal-pressure
186.	The nasal cavity is packed with __________ when looking for CSF rhinorrhea.	**186.**	pledgets
187.	Intensity of thallium uptake in primary brain tumors is related to__________.	**187.**	histologic grade
188.	Thallium uptake does not depend on breakdown of the blood–brain barrier. Rather, it is due to __________ across the cell membrane, which is increased in malignant tissues.	**188.**	active transport
189.	__________ brain tumor imaging is superior to MRI in distinguishing between recurrent tumor and edema or gliosis.	**189.**	Thallium
190.	Thallium brain imaging is useful in distinguishing __________ from __________ in HIV-positive patients.	**190.**	toxoplasmosis; lymphomas
191.	Patients with __________ encephalitis may show abnormal radiotracer uptake in the temporal lobes before positive findings are seen on CT.	**191.**	herpes simplex
192.	A peripheral, crescent-shaped area of increased Tc-DTPA uptake best describes a __________.	**192.**	subdural hematoma

For questions 193 through 198, match the statement with the appropriate brain radiopharmaceutical by choosing among the following: ^{123}I-IMP, ^{99}Tc-HMPAO, ^{99m}Tc-DTPA, all three, or none.

193.	Does not normally cross the blood–brain barrier.	**193.**	^{99m}Tc-DTPA
194.	Redistributes over several hours.	**194.**	^{123}I-IMP

195. Requires preparation with oral perchlorate to block unwanted choroid plexus uptake.

195. none

196. Can be used to establish the presence of brain death.

196. all three

197. Subacute stroke appears as an area of increased uptake.

197. ^{99m}Tc-DTPA

198. Static study is generally performed 1 hour or longer after injection.

198. ^{99m}Tc-DTPA

199. The most characteristic pattern suggesting Alzheimer's disease on a functional brain scan is:

a) symmetric decrease in frontal perfusion
b) asymmetric basal ganglia uptake
c) symmetric decrease in anteroparietal perfusion
d) symmetric decrease in posterior parietotemporal perfusion
e) none of the above

199. d, symmetric decrease in posterior parietotemporal perfusion

200. Intraictal findings in focal seizure disorders on a functional brain scan may include:

a) a localized area of increased uptake
b) a localized area of decreased uptake
c) a wider area of decreased perfusion than would be predicted from the clinical symptomatology
d) decreased perfusion in the thalamic region
e) none of the above

200. a, a localized area of increased uptake

201. The amount of injected dose of ^{99m}Tc-HMPAO (Ceretec) that actually localizes in the brain is:

a) 4 to 6%
b) 10 to 15%
c) 20 to 25%
d) 40 to 50%
e) 70 to 80%

201. a, 4 to 6%

202. True or false: Abnormal findings on ^{99m}Tc-HMPAO SPECT images in seizure patients generally parallel findings on ^{18}F-FDG-PET image studies.

202. True.

203. SPECT functional brain imaging has contributed to patient management in:

a) transient ischemic attacks
b) epilepsy
c) cocaine abuse
d) all of the above
e) none of the above

203. d, all of the above

204. Following lumbar subarachnoid installation of the radiopharmaceutical, current standard protocol indicates that the proper time frame to visualize the activity around the convexity of the brain is after:

a) 4 hours
b) 12 hours
c) 24 hours
d) 48 hours
e) 72 hours

204. c, 24 hours

205. The current agent of choice for radionuclide cisternography is:

a) ^{99m}Tc–human serum albumin
b) ^{111}In-chloride
c) ^{99m}Tc-DTPA
d) ^{111}In-DTPA
e) none of the above

205. d, ^{111}In-DTPA

206. True or false: Persistent ventricular filling and delayed transit around the brain convexity on a radionuclide cisternogram is consistent with normal-pressure hydrocephalus.

206. True.

207. ^{99m} Tc-hexamethylpropyleneamine oxime (HMPAO) flow, blood pool, and delayed images (▶Fig. 7.1a–c) demonstrate (choose all that apply):

a) internal carotid arterial flow
b) trident appearance of the intracerebral vessels
c) “hot nose” sign due to external carotid flow
d) intracerebral and sagittal sinus activity

207. a and c

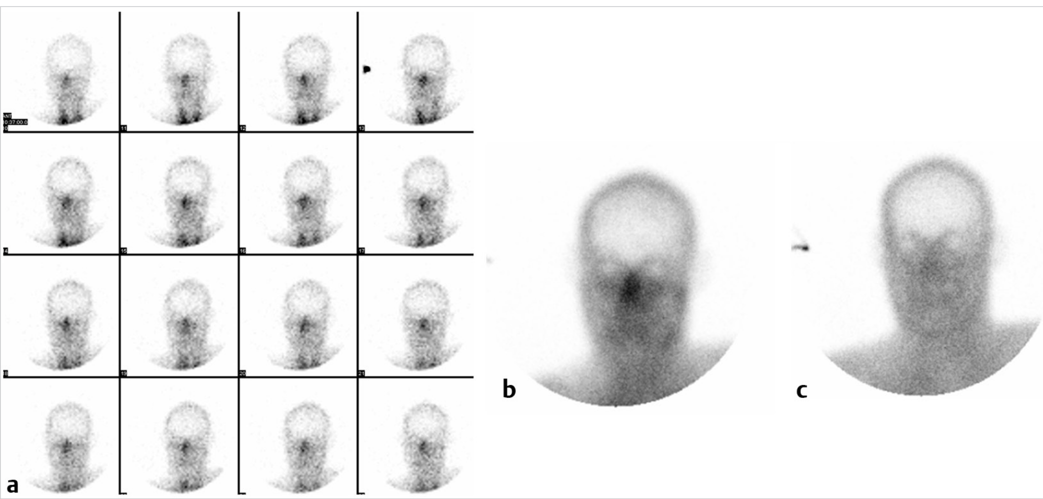

Fig. 7.1

208. 38-year-old man with AIDS and known brain mases underwent thallium-201 brain SPECT imaging (▶Fig. 7.2) to differentiate toxoplasmosis from CNS lymphoma.

In regard to the test results, false negative thallium-201 imaging in CNS lymphoma can be related to which of the following factors?

a) Small lesion size
b) Brainstem location
c) Low tumor grade
d) None of the above

208. a, b, and c

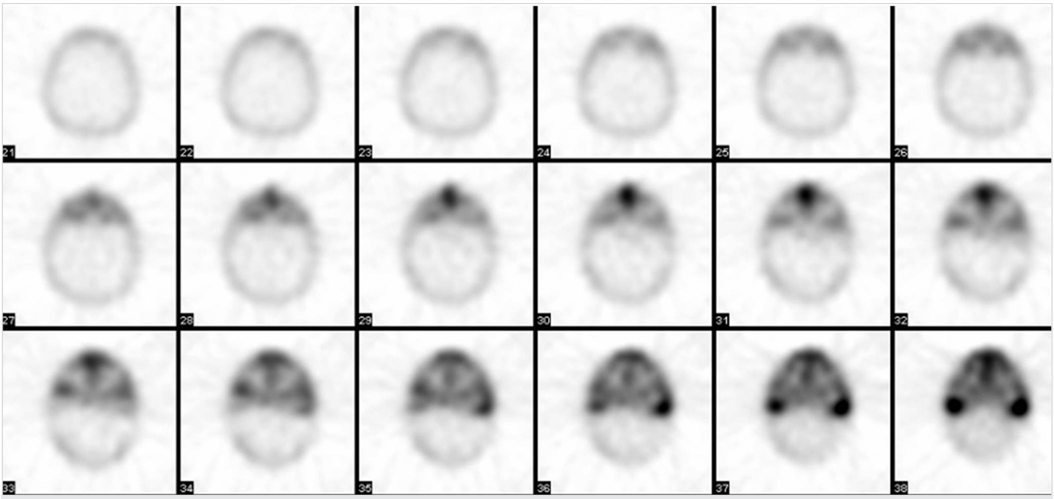

Fig. 7.2

209. Axial SPECT images from a thallium-201 brain SPECT are shown below (▶Fig. 7.3).

Findings are consistent with which one of the following diagnosis?

a) Toxoplasmosis infection
b) Encephalitis
c) CNS lymphoma
d) Artifact

209. c

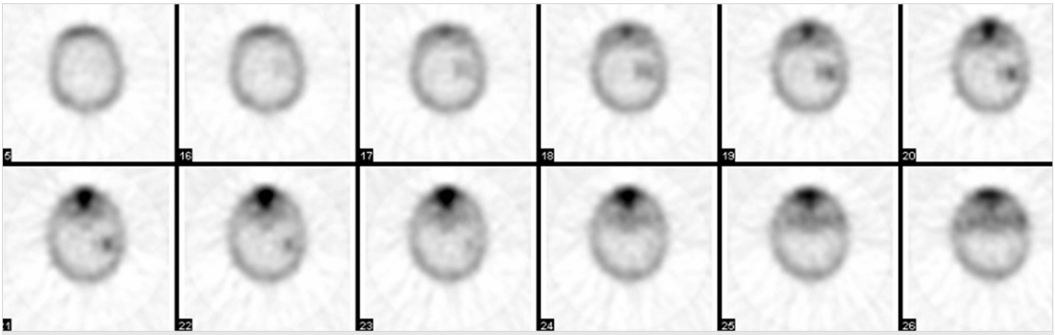

Fig. 7.3

210. 89-year-old woman with memory loss underwent [18]FFDG-PET/CT brain imaging (▶Fig. 7.4a–c).

The most likely diagnosis is:

a) Alzheimer's disease
b) frontotemporal dementia
c) Lewy body dementia
d) AIDS dementia

210. b

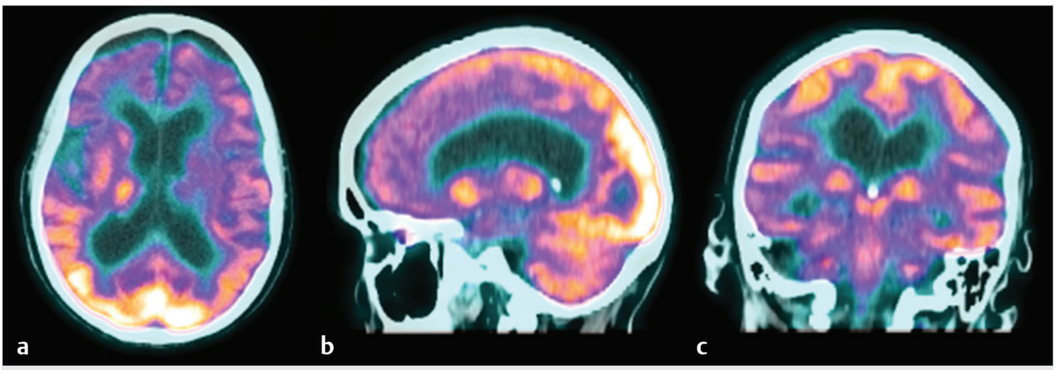

Fig. 7.4

211. 71-year-old man with memory loss underwent Florbetapir F18 (Amyvid) PET/CT brain imaging (▶Fig. 7.5).

True or false: Amyvid PET scan results are indicative of the brain neuritic amyloid plaque content only at the time of image acquisition and a negative scan result does not preclude the development of brain amyloid in the future.

211. True.

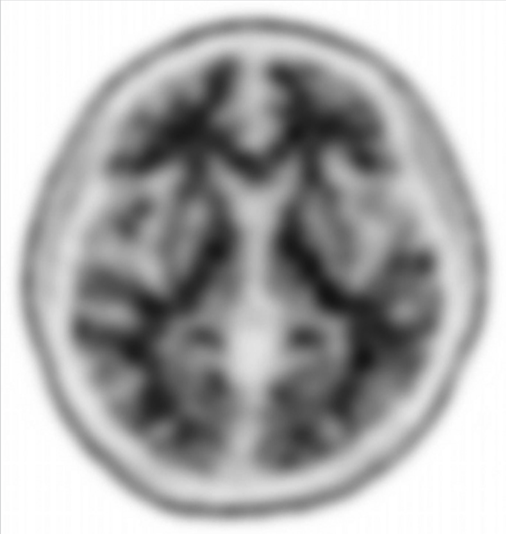

Fig. 7.5

212. True or falls: The Florbetapir F18 (Amyvid) PET scan images shown below are positive for amyloid neuritic plaques (▶Fig. 7.6a-c).

212. False.

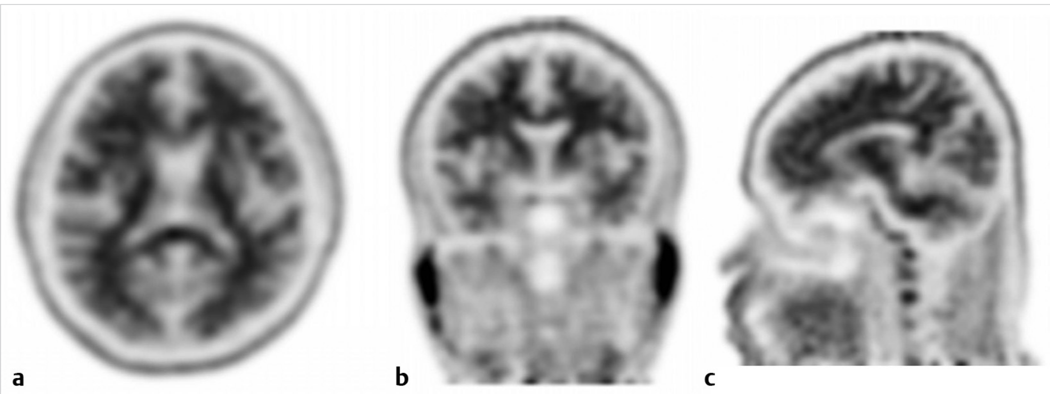

Fig. 7.6

213. Which of the following is true regarding Florbetapir F18 (Amyvid) and the results of this PET examination (▶Fig. 7.7)?

(Choose all that apply)

a) Used for PET imaging of beta-amyloid neuritic plaques.
b) FDA-approved tracer for evaluation for Alzheimer's disease and other causes of cognitive decline.
c) Positive Amyvid scan indicates moderate to frequent amyloid neuritic plaques.
d) This study is positive for amyloid neuritic plaques.
e) All of the above.

213. e, all of the above

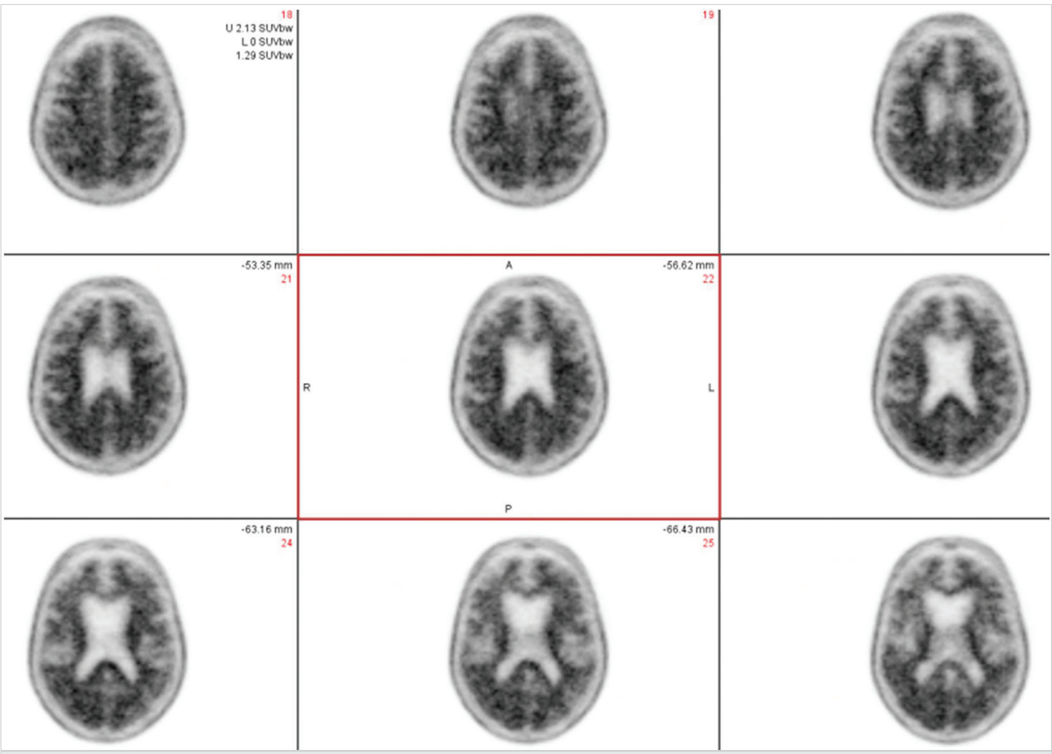

Fig. 7.7

214. 79-year-old man with memory loss underwent ^{18}FFDG-PET/CT brain imaging. Selected images are demonstrated (▶Fig. 7.8a, b).

Which one of the following is the most likely explanation for the appearance of the brain on this examination?

a) Vascular dementia
b) Frontotemporal dementia
c) Alzheimer's dementia
d) Lewy body dementia

214. c

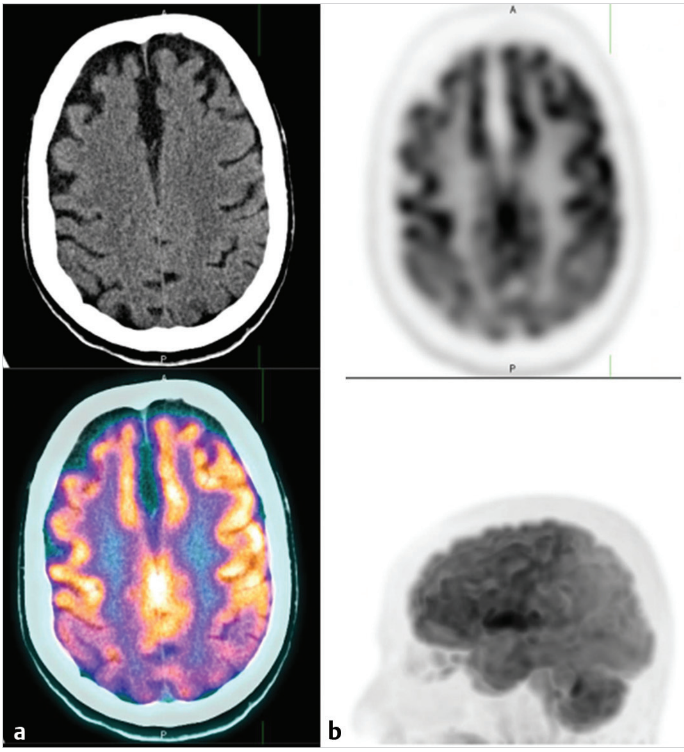

Fig. 7.8

215. Selected brain SPECT images are demonstrated (▶Fig. 7.9).

Which one of the following is the most likely radiotracer used for imaging?

a) ^{18}F-FDG
b) DaTscan (Ioflupane I 123)
c) ^{99m}Tc-HMPAO
d) Tc99m-DTPA

215. b

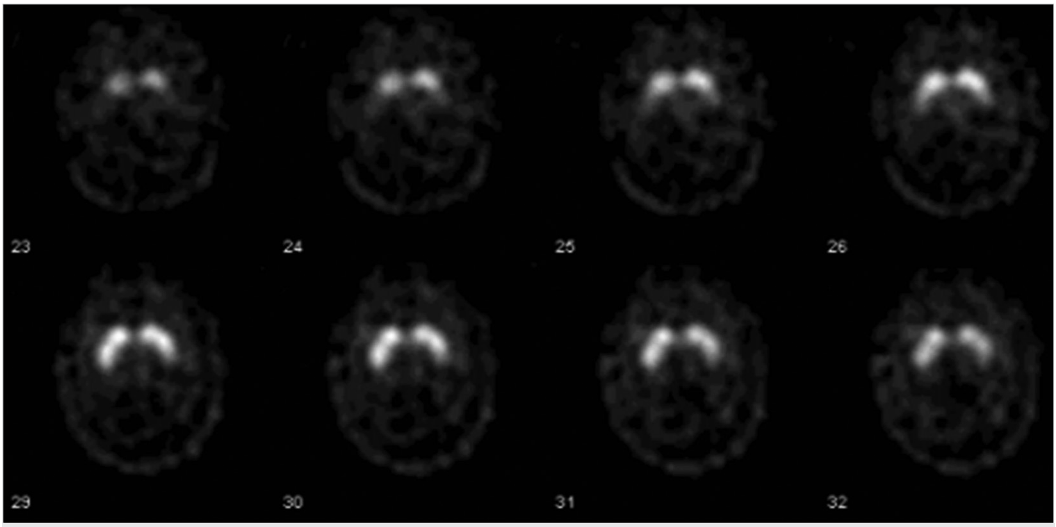

Fig. 7.9

216. 41-year-old man with known left middle cerebral artery stenosis underwent ^{99m}Tc-HMPAO brain SPECT imaging at baseline and after acetazolamide (Diamox) challenge to assess the cerebral perfusion reserve.

Baseline (▶Fig. 7.10a) and a Diamox challenge (▶Fig. 7.10b)
Which of the following is true regarding the Diamox challenge study and the results of this examination?

a) Acetazolamide is a carbonic anhydrase inhibitor that causes vasodilatation and increased flow in normal cerebral vessels.
b) Areas of limited flow reserve will have decreased tracer activity on the challenge exam compared to the baseline study.
c) The above images demonstrate fixed defect in the left middle cerebral artery distribution.
d) The above images demonstrate partially reversible ischemia in the left middle cerebral artery distribution.

216. a, b, d

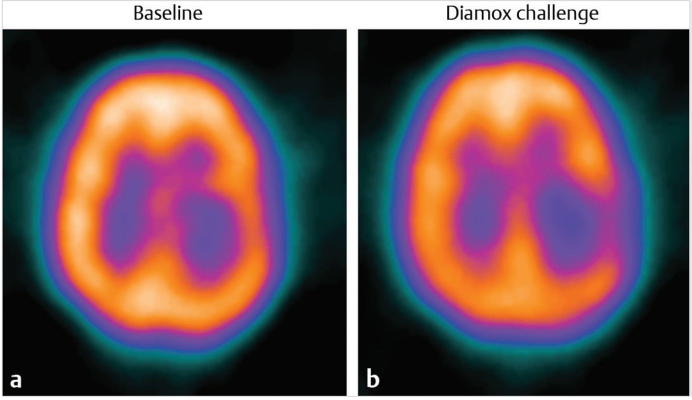

Fig. 7.10

217. 68-year-old male underwent ^{18}F-FDG-PET/CT for staging of non–small cell lung cancer (▶Fig. 7.11a–c).

Which of the following is true regarding the FDG-PET imaging of brain metastases? (Choose all that apply.)

a) FDG uptake in brain metastases does not depend on tumor histology.
b) Central hypometabolism in a brain lesion suggests necrosis.
c) The brain metastases are frequently surrounded by photopenia corresponding to areas of vasogenic edema.
d) FDG uptake in low-grade tumors is usually similar to white matter.

217. b, c, d

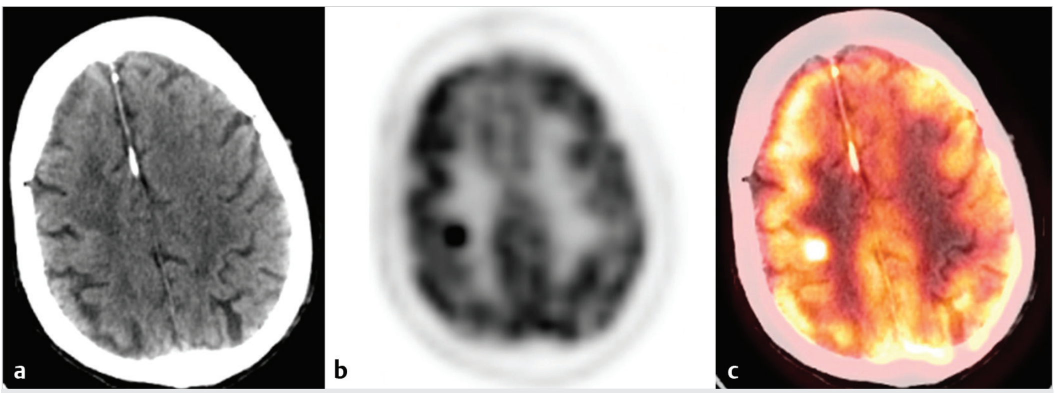

Fig. 7.11

218. I-123 FP-CIT (DaT scan) is approved for evaluation of:

a) Parkinsonian syndrome
b) Alzheimer's disease
c) Lewy body dementia
d) Huntington's chorea

218. a

219. (▶Fig. 7.12)

Imaging findings are most consistent with which of the following diagnoses?

a) meningioma
b) left middle cerebral artery infarct
c) neuroendocrine metastasis
d) glioma

219. a

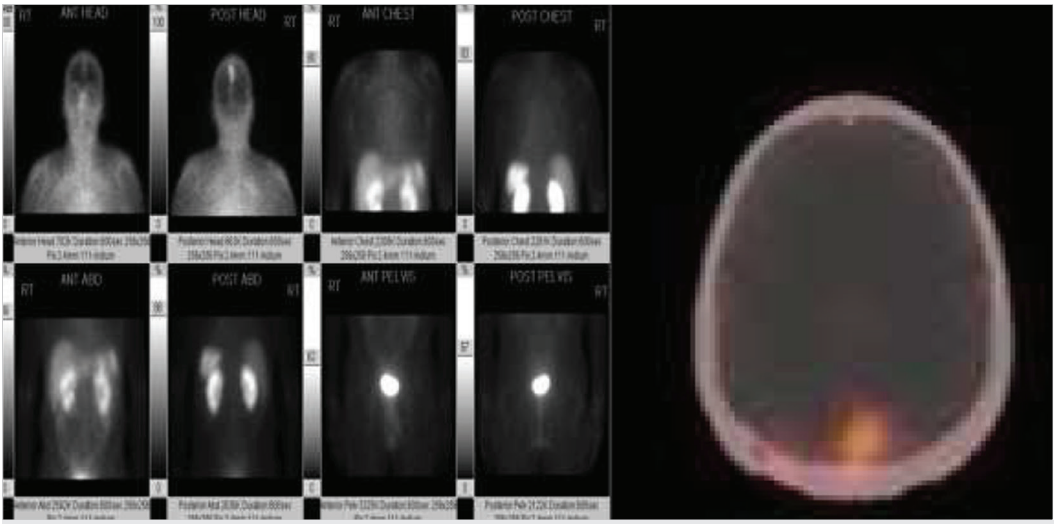

Fig. 7.12

8 Thyroid Gland and Endocrine System

Questions

1. What is the main difference between how the thyroid gland handles iodine and how it handles pertechnetate?
2. What are three disadvantages to using ^{131}I for thyroid imaging?
3. What are the main contaminants of commercial ^{131}I?
4. Name three advantages of ^{99m}Tc-pertechnetate over ^{123}I for thyroid imaging.
5. What percentage of a dose of radioiodine is taken up by the thyroid of a euthyroid individual at 24 hours after dosing?
6. What percentage of a dose of radioiodine is taken up by the thyroid of a euthyroid individual at 4 to 6 hours after dosing?
7. What percentage of a dose of ^{99m}Tc-pertechnetate is taken up by the thyroid of a euthyroid individual at 20 minutes after dosing?
8. How long does nursing need to be stopped for diagnostic doses of ^{123}I for mothers?
9. How long does nursing need to be stopped for diagnostic doses of ^{99m}Tc-pertechnetate for mothers?
10. For mothers, how long must nursing be stopped after uptake doses of ^{131}I?
11. True or false: For mothers, nursing should be stopped completely after ^{131}I therapeutic doses.
12. When does the fetal thyroid gland begin to concentrate iodine?
13. How does exogenous iodine affect thyroid uptake of radioiodine?

Answers

1. The thyroid gland organifies iodine but not technetium.
2. ^{131}I emits a beta (β) particle, has a high gamma (γ) energy, and has a long half-life; these factors combine to result in a high radiation dose to the thyroid.
3. ^{124}I and ^{125}I. (These contaminants increase the radiation dose.)
4. Cost, convenience (one patient visit), and availability.
5. 10 to 30%.
6. 4 to 15%.
7. 0.5 to 3.5%.
8. 2 to 3 days.
9. 12 to 24 hours.
10. Several weeks.
11. True.
12. At 12 weeks of gestation.
13. Exogenous iodine suppresses thyroid uptake of radioiodine.

14. Which of the following factors are important when the uptake of radioactive iodine is considered?

a) Food/intake history
b) Drug/medication history
c) Intravenous contrast administration
d) All of the above
e) None of the above

14. d, all of the above

15. What is the dose of ^{99m}Tc-pertechnetate for thyroid imaging?

15. 1 to 10 mCi (37–370 MBq).

16. What is the standard time procedure of delay between injection of ^{99m}Tc-pertechnetate and imaging?

16. 20 minutes.

17. What type of collimator is usually used for ^{99m}Tc-pertechnetate thyroid imaging?

17. A pinhole or high-resolution parallel.

18. What route is used to administer radioiodine?

18. Oral.

19. What is the dose of ^{123}I for thyroid imaging?

19. 100 to 400 µCi (3.7–14.8 MBq).

20. What is the usual time between administration of ^{131}I and imaging?

20. 24 hours.

21. What type of collimator is usually used for ^{123}I thyroid imaging?

21. A pinhole or high-resolution parallel.

22. What is the dose of ^{131}I for thyroid whole-body imaging for thyroid cancer?

22. 2 to 5 mCi (74–185 MBq).

23. What is the usual time between administration of ^{131}I and the start of whole-body imaging of thyroid cancer?

23. 1 to 3 days.

24. What type of collimator is usually used for detection of thyroid cancer via ^{131}I whole-body imaging?

24. High-energy parallel.

25. How are markers used for thyroid imaging?

25. Markers are used to show the location of the sternal notch, chin, thyroid cartilage, and palpable nodules.

26. In an adult, how much does a normal thyroid gland weigh?

26. Approximately 15 to 20 g.

27. In an adult, what are the length and breadth of a normal thyroid gland?

27. 4 to 5 cm by 1.5 to 2 cm.

28. What is meant by the term "pyramidal lobe"?

28. A pyramidal lobe is functioning thyroid tissue in the thyroglossal duct remnant that arises from the isthmus and extends superiorly just to the left or right of the midline.

29. How does one prove that activity on a thyroid scan is in the esophagus?

29. Have the patient drink water, and the activity will cease.

30. What is the normal pattern of uptake in the thyroid isthmus?

30. The isthmus may show uptake similar to a normal thyroid, or uptake may be absent.

31. What glands in the neck (other than the thyroid gland) can be visualized with thyroid imaging?

31. The salivary glands.

32. What four features should be described on a thyroid scan?

32. Thyroid size, homogeneity, and configuration; identification and description of hot and cold nodules; identification of extrathyroidal activity; and correlation of abnormalities with palpation.

33. Which of the following can cause thyrotoxicosis?

a) Iodine induced (Jod-Basedow)
b) Amiodarone (type I and type II)
c) Struma ovarii/benign ovarian teratoma
d) all of the above
e) none of the above

33. d, all of the above

34. What is the typical appearance of a benign nontoxic multinodular goiter?

34. Nonhomogeneous uptake with multiple cold areas of varying size.

35. What is the typical appearance of a goiter due to Graves' disease?

35. Homogeneously increased uptake.

36. What is the differential diagnosis of a goiter?

36. Multinodular goiter, Graves' disease, thyroid cancer, thyroid metastases, thyroiditis.

37. What is the purpose of a thyroid scan in the evaluation of a patient with a thyroid nodule?

37. To determine whether the nodule is single or multiple, hot or cold.

38. What is the risk of cancer in a solitary cold thyroid nodule?

38. 10 to 30%.

39. What is the risk of cancer in a warm thyroid nodule?

39. It should be considered the same as for a cold thyroid nodule.

40. How does a history of head/neck radiation affect the risk of cancer in a solitary cold thyroid nodule?

40. It moderately increases the risk of cancer.

41. What is the difference between an autonomous and nonautonomous hot thyroid nodule?

41. Autonomous nodules are not under the control of thyroid-stimulating hormone (TSH).

42. What finding on a thyroid scan demonstrates that a hot nodule is autonomous?

42. Suppression of the normal thyroid tissue.

43. What percentage of hot nodules are malignant?

43. Less than 1%.

44. How can nodules that are hot on ^{99m}Tc-pertechnetate imaging be cold on ^{123}I imaging?

44. Some thyroid neoplasms trap pertechnetate but cannot organify pertechnetate or iodine.

45. What percentage of nodules that are hot on ^{99m}Tc-pertechnetate imaging are cold on ^{123}I imaging?

45. 2 to 3%.

46. What radiopharmaceutical should be used to image substernal thyroids, and why?

46. ^{131}I; it has a high gamma (γ) energy that is unaffected by sternal attenuation.

47. What is the appearance of a sublingual thyroid on thyroid imaging?

47. A single mass of functional tissue at the base of the tongue with no activity within the normal thyroid bed location.

48. What is the appearance of thyroiditis on thyroid imaging?

48. Decreased or absent uptake in the affected part of the thyroid gland.

49. What types of thyroid cancers can be visualized on radioiodine imaging?

49. Follicular and papillary carcinomas.

50. What preparation is required for ^{131}I total body imaging for thyroid cancer?

50. Thyroid hormone must be withdrawn to increase TSH, or Thyrogen must be administered.

51. How is a thyroid uptake study performed?

51. The patient takes a dose of radioiodine; a camera measures activity in the neck, and a standard; the background corrected ratio of neck-to-standard counts is the uptake.

52. How is the thyroid uptake test useful in distinguishing thyroiditis from Graves' disease?

52. In thyroiditis, the uptake is abnormally low; in Graves' disease, the uptake is abnormally high.

53. How is ^{131}I used to treat Graves' disease?

53. The patient is given a dose adjusted for gland weight and uptake; alternatively, a standard treatment dose is used.

54. How do therapeutic doses of radioiodine for Graves' disease and for toxic nodule goiter differ?

54. Doses for a toxic nodule must be higher.

55. Which of the following is true regarding the absorbed thyroid dose?

a) ^{131}I equals 1 rad or 1 cGy/µCi.
b) ^{123}I equals 1 rad or 1 cGy/100 µCi.
c) ^{99m}Tc-pertechnetate equals 1 rad or 1 cGy/5,000 µCi.
d) All of the above.
e) None of the above.

55. d, all of the above

56. How do you recognize a whole-body thyroid scan?

56. Normal biodistribution includes stomach and urinary clearance. Remnant thyroid activity and/or metastatic disease might be seen. ^{123}I demonstrates better image quality compared with an ^{131}I whole-body scan. (See also Appendix A.)

57. True or false: Thyroid imaging with ^{99m}Tc-pertechnetate has additional salivary gland uptake and increased background activity compared with ^{123}I images.

57. True.

58. True or false: Discordant thyroid nodules (as the term is generally used) do not concentrate ^{99m}Tc-pertechnetate.

58. False.

59. True or false: Scintigraphic visualization of a pyramidal lobe in a hyperthyroid patient favors the diagnosis of toxic nodular goiter.

59. False.

60. True or false: The great majority of cold thyroid nodules are benign.

61. A whole-body survey (postthyroidectomy) for metastatic thyroid cancer is generally performed with what dose of radioiodine?

a) 100 to 200 µCi (3.7–7.4 MBq) of ^{131}I
b) 0.5 to 1.0 mCi (18.5–37 MBq) of ^{131}I
c) 1 to 5 mCi (37–185 MBq) of ^{131}I
d) 9 to 15 mCi (333–555 MBq) of ^{131}I
e) None of the above

62. True or false: Papillary adenocarcinoma of the thyroid gland most commonly spreads hematogenously to bone and lung tissues.

63. True or false: The size of the thyroid gland can be estimated quite well on a gamma camera image.

64. True or false: Thyroglossal tract cysts often contain thyroid tissue that functions on ^{131}I or ^{99m}Tc-pertechnetate scans.

For questions 65 through 68, match the clinical entity with the appropriate radiopharmaceutical by choosing from the following: ^{111}In-octreoscan, ^{131}I-metaiodobenzylguanidine (MIBG), ^{131}I-iodocholesterol (NP-59).

65. Pituitary adenoma

66. Medullary carcinoma of the thyroid

67. Pheochromocytoma

68. Carcinoid tumor

69. ^{99m}Tc-sestamibi uptake may be found in:

a) parathyroid hyperplasia
b) parathyroid adenoma
c) thyroid adenoma
d) all of the above
e) none of the above

70. True or false: An elevated level of thyroid-stimulating immunoglobulin is specific for Graves' disease.

71. After a total thyroidectomy, thyroid replacement is withheld to allow the TSH level to rise. A TSH level greater than __________ mU/mL should be reached before the ^{131}I whole-body scan is done.

60. True.

61. c, 1 to 5 mCi (37–185 MBq) of ^{131}I

62. False.

63. False.

64. False.

65. ^{111}In-octreoscan

66. ^{111}In-octreoscan

67. ^{131}I-metaiodobenzylguanidine (MIBG)

68. ^{111}In-octreoscan

69. d, all of the above

70. True.

71. 30

72. Which of the following is best for detecting thyroid carcinoma metastasis?

a) ^{131}I
b) ^{99m}Tc-sestamibi
c) ^{125}I
d) Tc-pertechnetate
e) none of the above

72. a, ^{131}I

73. When circulating thyroid hormone is low, the negative feedback mechanism induces the pituitary:

a) to increase pituitary synthesis of TSH
b) to suppress pituitary synthesis of TSH, which in turn decreases iodine trapping, hormonal synthesis, and its release by the thyroid

73. a, to increase pituitary synthesis of TSH

74. Graves' disease is a systemic immunologic process; almost all patients with Graves' disease have multiple antibodies to __________.

74. TSH receptors

75. Ophthalmopathy and skin changes are seen only in __________ and not in other forms of thyrotoxicosis.

75. Graves' disease

76. True or false: The effect of ^{131}I therapy on the progression of ophthalmopathy is heavily debated in current medical literature.

76. True.

77. Medullary thyroid carcinoma can occur as an isolated lesion or in association with __________ syndrome.

77. multiple endocrine neoplasia

78. Describe the components of multiple endocrine neoplasia (MEN) syndromes IIa and IIb.

78. MEN IIa: Medullary thyroid carcinoma, pheochromocytoma, hyperparathyroidism. MEN IIb: Medullary thyroid carcinoma; pheochromocytoma; marfanoid habitus; mucosal neuromas involving the lips, tongue, eyes, and pharynx; and ganglioneuromatosis of the gastrointestinal tract.

79. Define the classifications used to describe high-risk thyroid malignancy patients.

79. AMES (age of patient, presence of distant metastatic lesions, and extent and size of the primary cancer), AGES (patient age and tumor grade, extent, and size), TNM (tumor characteristics, lymph node involvement, and distant metastatic lesions), and MACIS (metastatic lesions, patient age, completeness of resection, invasion, and size of tumor).

80. What is rhTSH?

80. rhTSH is a highly purified recombinant form of human TSH synthesized in a Chinese hamster ovary cell line; it is an alternative for those who cannot tolerate thyroid hormone withdrawal prior to a diagnostic scan or therapy.

81. True or false: 0.9 mg of rhTSH is administered intramuscularly on two consecutive days prior to the administration of a diagnostic radioiodine dose on the third day. Serum Tg levels are also measured during the scan time period.

81. True.

82. True or false: After bilateral thyroidectomy and successful radioiodine ablation, serum Tg should be undetectable (less than 2 ng/mL).

82. True.

83. True or false: Intracranial and spinal metastatic lesions should be excluded so that an appropriate consult and steroid administration can be performed before withdrawal of thyroid hormone or rhTSH administration.

83. True.

84. Define a maximal safe dose of ^{131}I for therapy.

84. A safe dose is defined as the dose that delivers a maximum of 200 rad (2 Gy) to the blood with whole-body retention at less than 120 mCi (4.4 GBq) at 48 hours and with the amount in the lungs at less than 80 mCi (2.9 GBq) when pulmonary uptake is diffuse.

85. True or false: A retained dose to the lungs of more than 80 mCi (2.9 GBq) or a cumulative dose of 600 mCi (22.2 GBq) can result in radiation-induced pneumonitis or fibrosis.

85. True.

86. True or false: A cumulative dose of 800 mCi (29.6 GBq) of ^{131}I can result in significant bone marrow toxicity.

86. True.

87. Which tracer is most commonly used for imaging of the parathyroid glands?

87. ^{99m}Tc-sestamibi.

88. Which tracers can be used in association with ^{99m}Tc-sestamibi for thyroid imaging?

88. ^{123}I or ^{99m}Tc-pertechnetate.

89. True or false: Parathyroid adenoma typically demonstrates early hyperconcentration and delayed washout when compared with the thyroid gland on ^{99m}Tc-sestamibi study.

89. True.

90. Which of the following is true regarding parathyroid scintigraphy?

a) A common cause of a false-positive is thyroid adenoma.
b) A common cause of a false-negative is a smaller parathyroid adenoma or hyperplasia.
c) SPECT provides better sensitivity and anatomical localization.
d) It is useful in identification of ectopic adenomas (1–5%).
e) It is recommended in cases of re-exploration.
f) It is useful in preoperative planning for minimally invasive parathyroidectomy.
g) All of the above.

90. g, all of the above

91. How do you recognize an ^{123}I MIBG scan?

91. Normal biodistribution includes liver, spleen, salivary glands, myocardial, and mild thyroid uptake. Urinary bladder and intestinal activity are also seen. There is absence of bone marrow activity.

92. Which of the following are applications for an MIBG scan?

a) Neuroblastoma
b) Pheochromocytoma
c) Medullary carcinoma of thyroid, carcinoid
d) Investigational role for ^{131}I MIBG therapy of tumors
e) All of the above

92. e, all of the above

93. History of papillary thyroid cancer status post thyroidectomy. Patient was treated with radioactive iodine at an outside hospital (▶Fig. 8.1). Which of the following is correct?

a) No treatment is required.
b) Check thyroglobulin.
c) There is metastasis to stomach.
d) There is adrenal metastasis.

93. b

94. In the same patient, thyroglobulin is 423 ng/dL. What is next best step?

a) Follow up next year.
b) Obtain PET CT scan.
c) Treat with radioactive iodine.
d) Obtain another ^{131}I scan.

94. b

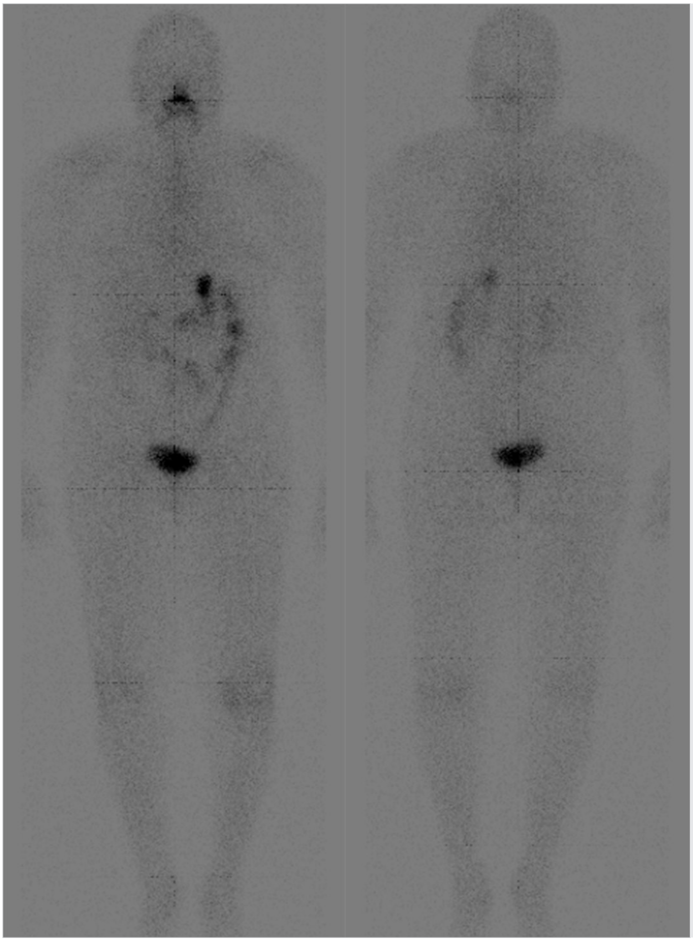

Fig. 8.1

95. 50-year-old woman with elevated calcium underwent early and delayed sestamibi imaging followed by a pertechnetate image (▶Fig. 8.2).

Which of the following is (are) true:

a) The findings are compatible with right lower pole parathyroid adenoma.
b) The findings are highly suspicious for right lower pole thyroid cancer.
c) The findings exclude parathyroid carcinoma.
d) The technetium pertechnetate image reduces the likelihood of thyroid cancer.
e) Previous neck surgery interferes with parathyroid scintigraphy.

95. a, d

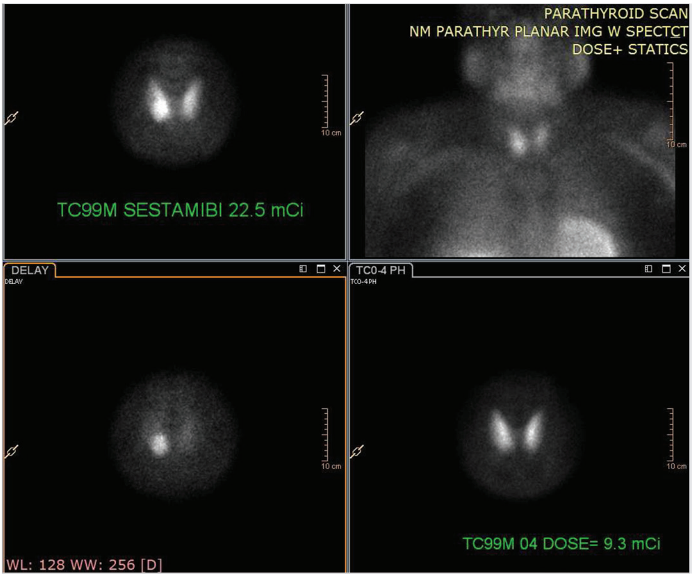

Fig. 8.2

96. 58-year-old man with carcinoid tumor of bronchus metastasized to liver is scheduled for selective internal radiation therapy (SIRT) to the liver with Y-90. In preparation for treatment, mapping was performed. 4 mCi TcMAA was selectively injected via catheter into the right hepatic artery in the interventional radiology suite and 30 minutes later chest and upper abdomen changes were obtained in the nuclear medicine section (▶Fig. 8.3).

Which of the following is (are) true:

a) The 2.9% shunting to the lungs is too high to safely perform the radioembolization.
b) Faint thyroid visualization is not of clinical concern.
c) The images suggest substantial exposure of intraabdominal organs.
d) Based on these images, it is not safe to proceed to SIRT.

96. b

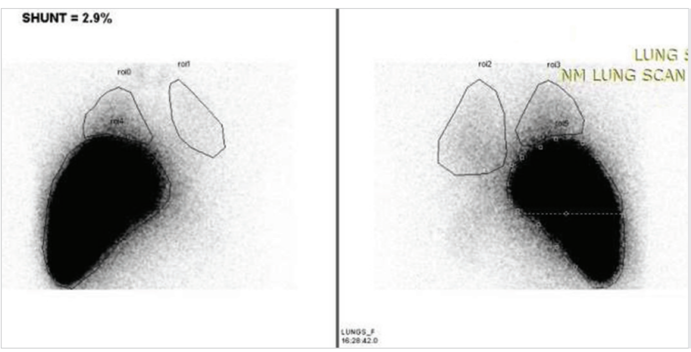

Fig. 8.3

97. 50-year-old woman underwent imaging with 2 mCi ^{99m}Tc-pertechnetate (▶ Fig. 8.4).

The most likely diagnosis is:
a) hypofunctioning nodule in left lobe
b) hyperfunctioning nodule in right lobe
c) subacute thyroiditis involving the left lobe
d) subacute thyroiditis involving the right lobe

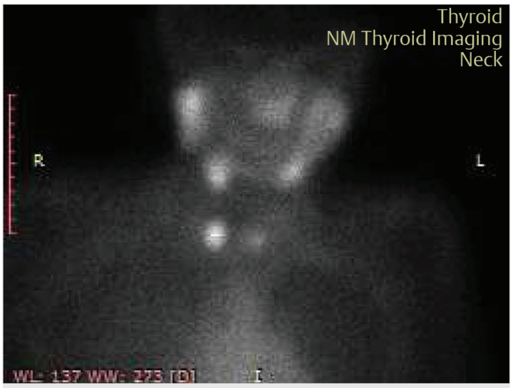

Fig. 8.4

98. 35-year-old woman presents with low TSH and palpitations (▶ Fig. 8.5).

The most likely diagnosis is:
a) subacute thyroiditis
b) Graves' disease
c) nontoxic nodular goiter
d) Hashimoto's thyroiditis

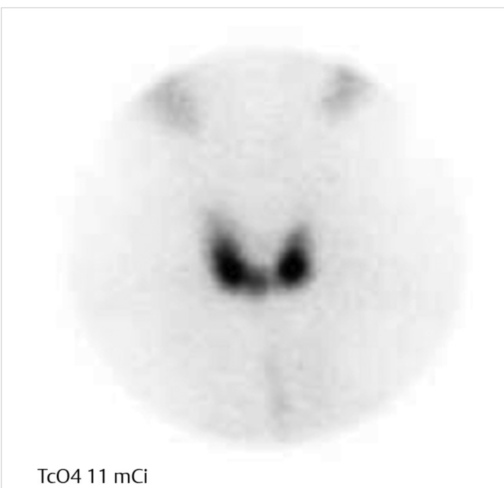

Fig. 8.5

97. b, uptake in the right lobe exceeds salivary gland uptake and uniformly suppresses the left lobe.

98. b

99. 25-year-old woman 4 months postpartum with weight loss and heat intolerance. Laboratory values confirm thyrotoxicosis with suppressed TSH and elevated T4. The 24-hour thyroidal uptake of radioactive iodine is 92% (▶Fig. 8.6).

The most likely diagnosis is:

a) autonomous nodule in right upper pole
b) postpartum thyroiditis
c) Graves' disease with cold nodule in right lower pole
d) Hashimoto's thyroiditis with cold nodule in right lower pole

99. c; A is a possible diagnosis but autonomous nodule is unusual in young adults and is not commonly associated with such high thyroidal radioiodine uptake.

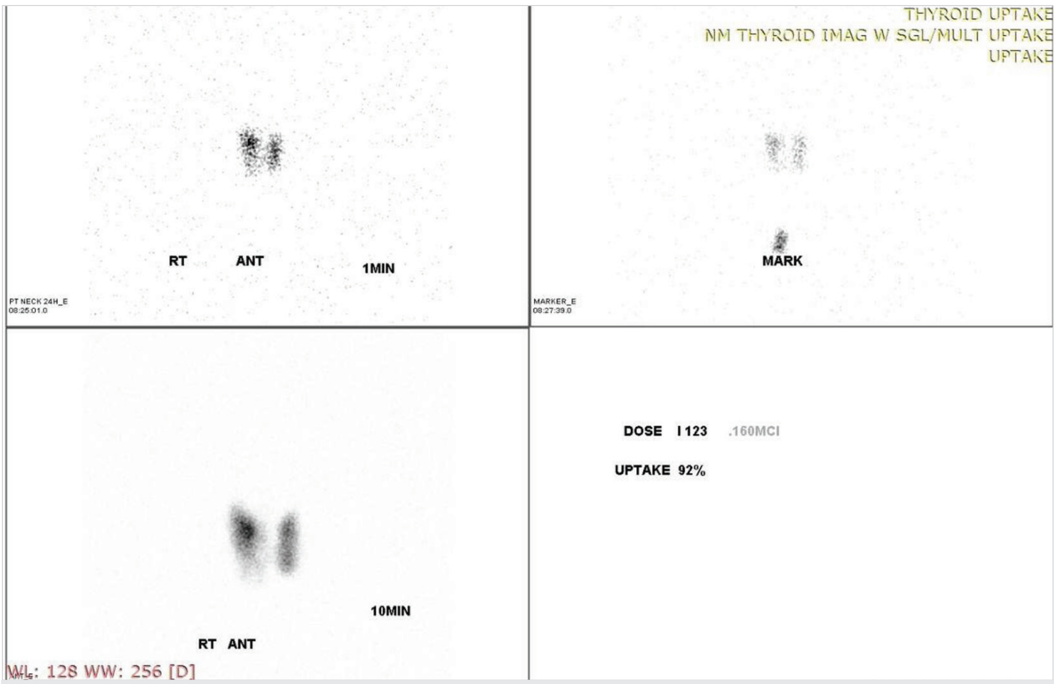

Fig. 8.6

100. A 50-year-old woman status post thyroidectomy for papillary carcinoma 1 month ago (▶Fig. 8.7).

The images most likely portray:

a) diagnostic scan obtained 48 hours after oral administration of 2 mCi showing uptake in the thyroid bed and a local metastases
b) imaging acquired 1 week after administration of 100 mCi ^{131}I showing residual tissue in the thyroid bed and a local metastasis undergoing ablation
c) diagnostic scan obtained at 48 hours showing residual tissue in the thyroid bed, a local metastasis, and metastases to liver
d) imaging acquired 1 week after administration of 100 mCi ^{131}I showing residual tissue in the thyroid bed and a local metastasis undergoing ablation and metastases to liver

100. b; uniform uptake in the liver is physiologic 1 week after ^{131}I administration; local absence of gastric and small bowel activity would be unusual for images obtained at 48 hours.

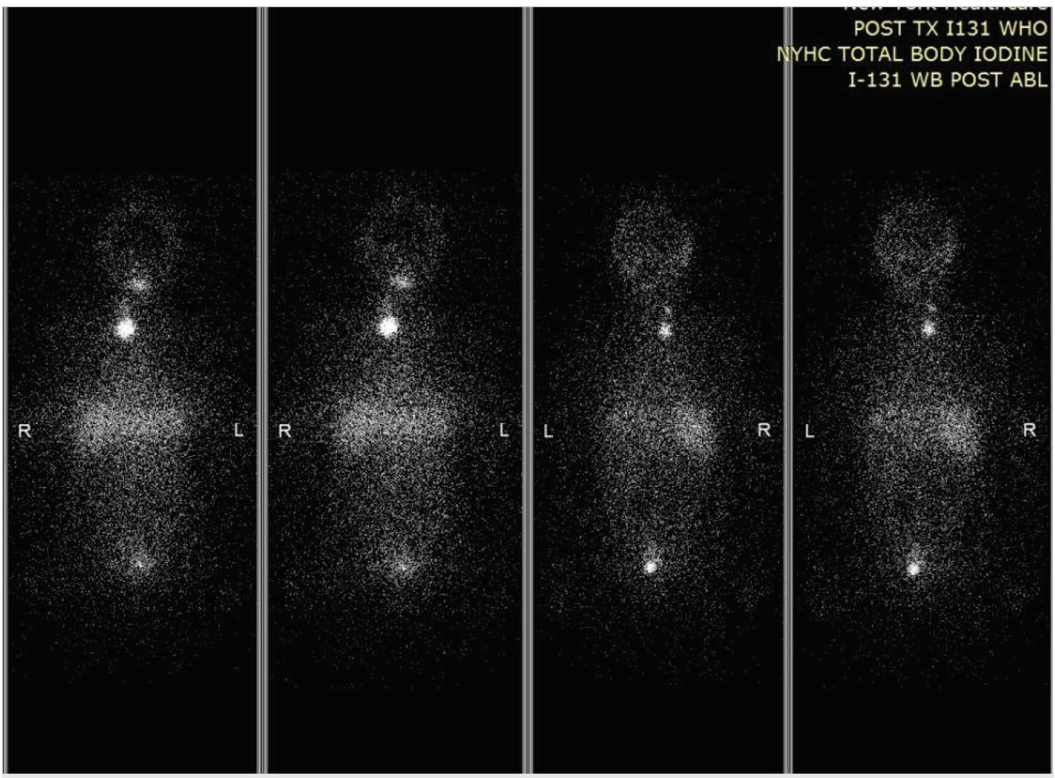

Fig. 8.7

101. A 50-year-old woman underwent total thyroidectomy for papillary carcinoma, classic type measuring 1 cm with extrathyroidal extension. pT3NxMx. 24-hour neck uptake was 1% (▶Fig. 8.8).

The most appropriate dose for ablation of remnant tissue and adjuvant therapy is:

a) 30 mCi ^{131}I
b) 125 mCi ^{131}I
c) No ablation is indicated.
d) SPECT/CT should be performed before determination whether to ablate and dose.

101. d

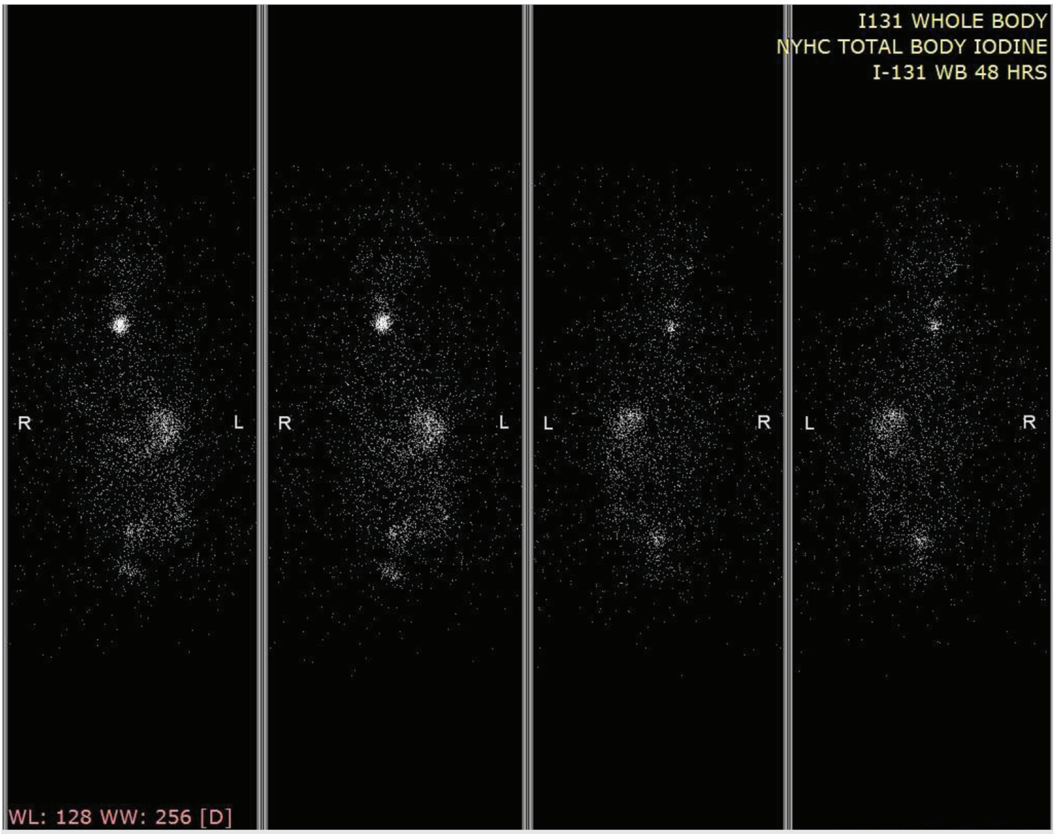

Fig. 8.8

102. This is the SPECT/CT of the previous patient (▶Fig. 8.9).

The best dose would be:

a) no ablation
b) 30 mCi
c) 125 mCi
d) 250 mCi

102. c. The SPECT/CT shows two foci of hyperactivity in the neck. A more superior and less intense focus located at right thyroidectomy bed is more consistent with a residual thyroid tissue. The second focus is more intense located at right pretracheal medial and posterior to the right clavicular head. This is more consistent with pretracheal lymphadenopathy rather than residual thyroid tissue at lower aspect of the right thyroid lobe.

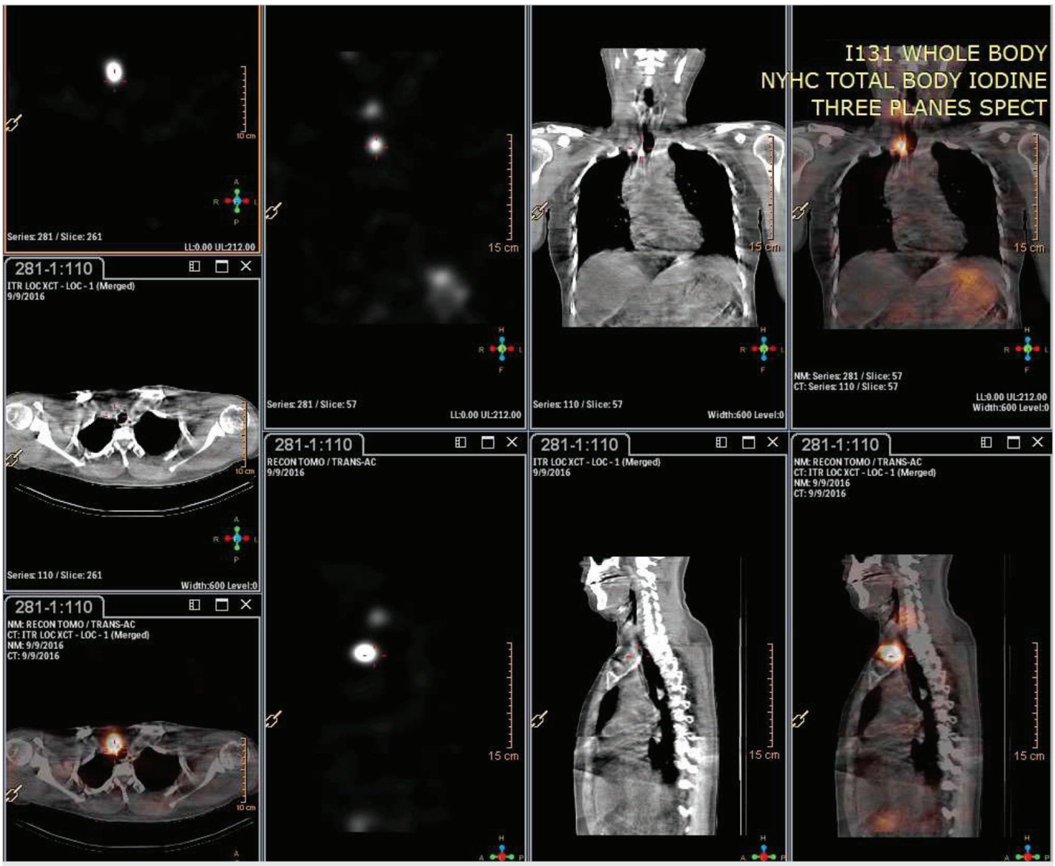

Fig. 8.9

103. A 53-year-old woman presents with diarrhea, abdominal cramping, flushing, dermatitis, and elevated serum 5-HIAA. An octreoscan with 6 mCi of ^{111}In-pentetreotide was performed with planar images at 24 hours (▶Fig. 8.10).

Which of the following is (are) true:

a) The planar images exclude carcinoid neoplasm.
b) The study is inconclusive without serial images preferably including SPECT at 4 and 24 hours.
c) In carcinoid syndrome, liver metastases are frequent.
d) The most common site for a primary carcinoid tumor is the small bowel.

103. b, c, d; terminal ileum or appendiceal carcinoid would be difficult to exclude without serial imaging; metastases to the liver is difficult to exclude without SPECT.

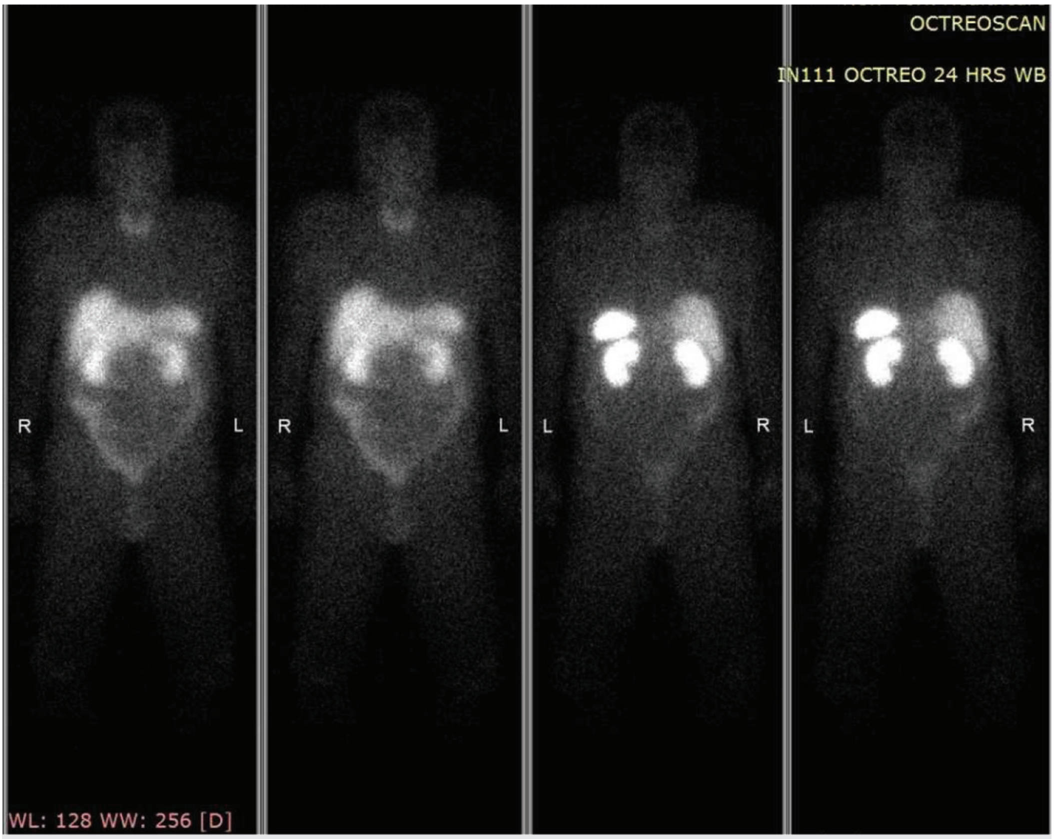

Fig. 8.10

104. A 70-year-old man with a history of papillary thyroid cancer treated 15 years ago with total thyroidectomy and ^{131}I ablation presents with serum thyroglobulin 20 ng/mL while on T4 suppression and stimulated thyroglobulin of 150ng/mL (▶Fig. 8.11).

Which of the following is (are) true?

a) The scan findings exclude recurrent thyroid cancer.
b) A reasonable next step would be PET-FDG scan.
c) A reasonable next step would be empirical treatment with 250 mCi.
d) A reasonable next step would be rescan with ^{131}I in a year.

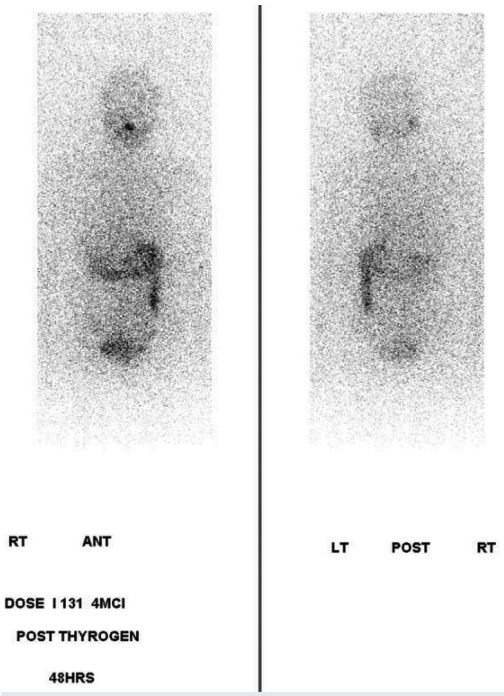

Fig. 8.11

104. b

9 Gastrointestinal

Questions

1. What type of meal is used for radionuclide esophageal transit scintigraphy?
2. What is the critical organ for oral ^{99m}Tc–sulfur colloid?
3. How are patients prepared for radionuclide esophageal transit scintigraphy?
4. How is a radionuclide esophageal transit scintigraphy performed?
5. Why are multiple swallows required for a radionuclide esophageal transit scintigraphy?
6. What is the definition of an “aberrant” swallow?
7. How does one calculate esophageal transit time?
8. Which esophageal abnormality can radionuclide esophageal scintigraphy detect most sensitively?
9. How are patients prepared for gastroesophageal reflux scintigraphy?
10. What are the radiopharmaceutical dose and meal used for gastroesophageal reflux scintigraphy in adults?
11. What images are obtained for gastroesophageal reflux scintigraphy in children?
12. Why is abdominal compression not used for gastroesophageal reflux scintigraphy in children?
13. What three features of reflux should be described in gastroesophageal reflux scintigraphy in children?

Answers

1. A liquid bolus.
2. The large intestine.
3. By an overnight fast.
4. The patient lies supine and practices swallowing nonradioactive boluses. Then the patient swallows a radioactive bolus, dry swallows at 30 seconds, and thereafter swallows a radioactive bolus every 30 seconds for 2 minutes.
5. There is a 25% incidence of aberrant swallows; multiple swallows give a more representative result.
6. A swallow followed by a dry swallow that inhibits the initial swallow and causes delayed transit.
7. The time from the initial entry of the bolus into the esophagus until all but 10% of the initial activity remains.
8. Achalasia.
9. By an overnight fast.
10. 300 µCi (11.1 MBq) of ^{99m}Tc–sulfur colloid in 150 mL of orange juice.
11. 5- to 10-second dynamic images of the anterior abdomen and chest for 60 minutes and a 2- to 4-hour delayed image of the chest to look for aspiration.
12. It is nonphysiologic and does not increase the detection rate of reflux in children.
13. The height of the reflux in the esophagus, the duration of the reflux, and the time from the meal.

14. What other radionuclide technique can be used for accurately detecting pulmonary aspiration?

14. A radionuclide salivagram, where the tracer is placed on the tongue and dynamic images are obtained.

15. What are the two functionally distinct areas of the stomach involved in gastric emptying?

15. The fundus and the antrum.

16. What are the common symptoms of delayed gastric emptying?

16. Early satiety, bloating, nausea, vomiting.

17. What are the symptoms of rapid gastric emptying?

17. Palpitations, diaphoresis, weakness, diarrhea.

18. What is the most common cause of chronic gastroparesis?

18. Diabetes.

19. What drugs are used to treat chronic gastroparesis?

19. Metoclopramide, domperidone, cisapride, erythromycin.

20. What tracer is used to measure liquid gastric emptying in single-isotope studies?

20. ^{99m}Tc–sulfur colloid.

21. What tracer is used to measure liquid gastric emptying in a dual-isotope study, simultaneous with solid-phase emptying?

21. ^{111}In-diethylenetriaminepentaacetic acid (DTPA).

22. What characteristics of a meal affect its rate of gastric emptying?

22. Liquidity, texture, volume, weight, particle size, caloric density, nutrient composition.

23. What is the standard scintigraphic meal for the evaluation of gastric emptying?

23. An egg-white meal (Egg Beaters or generic equivalent) radiolabeled with 0.5 to 1.0 mCi of ^{99m}Tc–sulfur colloid and toast and jam and 200-mL water.

24. What is the advantage of dual-isotope gastric emptying studies over solid-phase gastric emptying studies?

24. 20 to 30% of adults with normal solid gastric emptying have abnormal liquid emptying.

25. What are the relative sensitivities of solid- and liquid-phase gastric emptying studies?

25. The solid phase is more sensitive than the liquid phase (80 vs. 60%) to detect gastroparesis.

26. When should liquid-phase gastric emptying studies be performed?

26. When the patient cannot tolerate solids or when gastric emptying was normal.

27. True or false: Decay and attenuation corrections are utilized for calculation of gastric emptying half-time.

27. True.

28. Why is attenuation correction helpful in performing gastric emptying studies?

28. Movement of the meal from the posterior fundus to the anterior antrum can cause an increase in counts due to attenuation effects alone.

29. How is attenuation accounted for in gastric emptying studies?

29. Obtain anterior and posterior counts and calculate the geometric mean.

30. What is the current consensus on the imaging time periods for the evaluation of solid gastric emptying?

30. Imaging should at least be performed at the ingestion and 1, 2, 3, and 4 hours after the ingestion of the radiolabeled meal.

31. When does emptying of a liquid meal begin?

31. Immediately.

32. How does a coexisting solid meal affect the emptying of a liquid meal?

32. It slows the emptying of the liquid meal.

33. What is the half-life of a liquid meal in the stomach?

33. Approximately 10 to 20 minutes.

34. When does emptying of a solid meal begin?

34. After an initial lag phase.

35. What are the normal retention values at 1, 2, and 4 hours?

35. 1 hour, 37 to 90%; 2 hours, 30 to 60%; 4 hours, 0 to 10%.

36. What disease can cause an increased lag phase of gastric emptying?

36. Diabetes.

37. How are patients prepared for a gastric emptying study?

37. By an overnight fast.

38. How does the urea breath test work?

38. The patient is given ^{13}C- or ^{14}C-labeled urea orally; the presence of ^{13}C- or ^{14}C-labeled CO_2 in the breath indicates urea-splitting bacteria in the stomach, such as *Helicobacter pylori*.

39. How is gastrointestinal bleeding diagnosed by scintigraphy with ^{99m}Tc–sulfur colloid?

39. A focal area of tracer accumulation is seen that increases in intensity with time and moves within the gastrointestinal tract.

40. What are the causes of false-positive gastrointestinal bleeding scintigraphy with ^{99m}Tc–sulfur colloid?

40. Ectopic spleen, renal transplant uptake, asymmetric marrow uptake.

41. It is difficult to diagnose gastrointestinal bleeding with ^{99m}Tc–sulfur colloid in what areas of the gastrointestinal tract?

41. Splenic flexure and transverse colon, due to overlap of the liver and spleen.

42. How is a gastrointestinal bleeding scintigraphy performed with ^{99m}Tc–sulfur colloid?

42. The patient is injected with 10 mCi (370 MBq) of ^{99m}Tc–sulfur colloid; 1-second flow images are obtained for 60 seconds, followed by 1- to 2-minute dynamic images for 20 minutes.

43. How is a gastrointestinal bleeding scintigraphy performed with ^{99m}Tc–red blood cells (RBCs)?

43. The patient is injected with 25 mCi (925 MBq) of ^{99m}Tc-RBCs; 1- to 2-minute dynamic images are obtained for 60 to 90 minutes.

44. How is gastrointestinal bleeding diagnosed by scintigraphy with ^{99m}Tc-RBCs?

44. A focal area of tracer accumulation is seen that increases in intensity with time and moves within the gastrointestinal tract.

45. What is the main advantage of ^{99m}Tc-RBCs over ^{99m}Tc–sulfur colloid for the detection of gastrointestinal bleeding?

45. Longer imaging time and hence more sensitive. Still has to be actively bleeding during study.

46. What are the methods of labeling ^{99m}Tc with RBCs for gastrointestinal bleeding scintigraphy?

46. In vivo and in vitro.

47. Which method of labeling has the highest labeling efficiency?

47. In vitro (greater than 97%).

48. What drug can be given to enhance the sensitivity of gastrointestinal bleeding scintigraphy for small bowel bleeding?

48. Glucagon.

49. What is the significance of large bowel activity on 24-hour images in gastrointestinal bleeding scintigraphy with ^{99m}Tc-RBCs?

49. It indicates gastrointestinal bleeding but does not localize the site; the site could have been anywhere in the gastrointestinal tract with pooling in the large intestine.

50. A false-positive interpretation on a ^{99m}Tc-RBC-tagged study can result from:

a) free ^{99m}Tc-pertechnetate secreted by the gastric mucosa
b) pelvic structures such as ectopic kidneys, fibroids, uterus, and genitalia
c) renal pelvic retention of activity
d) abdominal aortic aneurysm
e) hepatic hemangioma, accessory spleen, varices
f) all of the above

50. f, all of the above

51. What rate of bleeding can be detected with gastrointestinal bleeding scintigraphy?

51. As low as 0.05 to 0.1 mL/minute.

52. What rate of bleeding can be detected with contrast mesenteric angiography?

52. 1 mL/minute or more.

53. What is the reported rate of bleeding that can be detected on a contrast-enhanced multidetector computed tomography (MDCT), given that the patient is actively bleeding during the scan period?

53. 0.3 mL/minute or more.

54. What volume of blood can be detected with gastrointestinal bleeding scintigraphy?

54. As little as 3 mL.

55. What is the whole-body radiation dose of gastrointestinal bleeding scintigraphy with ^{99m}Tc–sulfur colloid?

55. 0.190 rad (1.9 mGy).

56. What is the whole-body radiation dose of gastrointestinal bleeding scintigraphy with ^{99m}Tc-RBCs?

56. 0.4 rad (4 mGy).

57. What is the critical organ and its radiation dose for gastrointestinal bleeding scintigraphy with ^{99m}Tc–sulfur colloid?

57. The liver, with 3.4 rad (34 mGy).

58. What is the critical organ and its radiation dose for gastrointestinal bleeding scintigraphy with ^{99m}Tc-RBCs?

58. The spleen, with 2.2 rad (22 mGy).

59. What are the two main advantages of ^{99m}Tc–sulfur colloid over ^{99m}Tc-RBCs for the detection of gastrointestinal bleeding?

59. There are fewer false-positives, and the test is easier to interpret.

60. What is the target organ for ^{99m}Tc-pertechnetate?

60. The stomach.

61. What cell type in the stomach takes up ^{99m}Tc-pertechnetate?

61. The mucin-producing parietal cells.

62. What patient preparation is required for a Meckel scan?

62. 4 to 6 hours of fasting and no barium studies in the past 3 or 4 days.

63. ^{99m}Tc-pertechnetate abdominal imaging may be used to detect:

a) Barrett's esophagus
b) Meckel's diverticulum
c) retained gastric antrum
d) all of the above
e) none of the above

63. d, all of the above

64. All of the following have been proposed as pharmacologic interventions to enhance Meckel's diverticulum imaging except:

a) cholestyramine
b) pentagastrin
c) glucagons
d) cimetidine
e) all of the above

64. a, cholestyramine

65. What are the mechanisms of action of glucagon, pentagastrin, and cimetidine for gastrointestinal (GI) scintigraphy?

65. Glucagon, antiperistaltic effect; pentagastrin, increased pertechnetate uptake and secretion, similar to gastrin; cimetidine, histamine H_2-receptor blocker that inhibits pertechnetate secretion by mucin cells.

66. What are the sensitivity and specificity of a Meckel scan for ectopic gastric mucosa?

66. Sensitivity 85%, specificity 95% (in children).

67. True or false: In jaundiced patients, there is enhanced renal excretion of hepatobiliary tracer.

67. True. (With poor hepatic clearance and increased tracer in the blood pool, the degree of renal excretion is increased.)

68. True or false: Some hepatomas may accumulate the hepatobiliary tracer.

68. True. (Most hepatocellular carcinomas are cold on iminodiacetic acid [IDA] scans, but there are some well-differentiated tumors that have demonstrated IDA uptake.)

69. True or false: Serum bilirubin levels have no influence on the rate of blood pool clearance of diisopropyl iminodiacetic acid (DISIDA).

69. False. (Due to competitive inhibition of IDA analogs, high serum bilirubin levels interfere with tracer uptake.)

70. True or false: The critical organ for iminodiacetic acid (IDA) agents is the liver.

70. False. (It is the large bowel.)

71. True or false: Space-occupying lesions of the liver cannot be identified on hepatobiliary imaging.

71. False. (In the early or hepatic phase of the study, cold areas can be identified.)

72. True or false: Imaging in biliary atresia is more effective after phenobarbital administration.

72. True. (It enhances bilirubin conjugation and excretion and also the accumulation and excretion of IDA analogs.)

73. True or false: Boiling is one of the steps in the preparation of Tc-labeled hepatobiliary agents.

73. False. (Boiling is one of the steps in the preparation of ^{99m}Tc–sulfur colloid, a liver and spleen imaging agent.)

74. True or false: Approximately 20% of gallbladders with acute cholecystitis are visualized on hepatobiliary imaging.

74. True.

75. True or false: A rim of faintly increased activity of Tc-IDA agent in the liver tissue bordering the gallbladder fossa is specific for gangrenous cholecystitis.

75. False. (It increases the likelihood, however.)

76. True or false: Delayed or absent gallbladder filling in a patient with impaired hepatic uptake and clearance is a reliable sign of acute or chronic cholecystitis.

76. False. (Delayed gallbladder filling may be caused by the delayed entry of the tracer into the biliary system due to poor clearance.)

77. True or false: Hepatic tracer uptake of Tc-IDA is impaired in acute extrahepatic obstruction.

77. False. (Tracer uptake is prompt as long as hepatic function is intact.)

78. True or false: In an adult patient, nonvisualization of the bowel at 1 hour is diagnostic of complete extrahepatic obstruction.

78. False. (Severe intrahepatic cholestasis can give rise to a similar scan appearance.)

79. True or false: Biliary tract dilatation can be reliably diagnosed on Tc-IDA scintigraphy.

79. False. (Ultrasound is the study of choice for assessing the caliber of the biliary ducts.)

80. True or false: Obstruction of the cystic duct can be diagnosed with a reliability in excess of 90% with hepatobiliary imaging.

80. True. (The sensitivity is 95%.)

81. True or false: Retrograde flow of the hepatobiliary agent that is sufficient to allow visualization of the stomach indicates the presence of bilious gastritis.

81. False. (Biliary-gastric reflux does not correlate with gastric pathology and is a nonspecific finding.)

82. True or false: Administration of phenobarbital in patients with hyperbilirubinemia can induce cholestasis.

82. False. (It has the opposite effect.)

83. True or false: Poor hepatic uptake, along with nonvisualization of bowel on IDA scintigraphy, is the hallmark of biliary atresia.

83. False. (Good hepatic uptake with no excretion to the bowel is suggestive of biliary atresia.)

84. True or false: Hepatobiliary scintigraphy has a higher sensitivity than specificity for the diagnosis of biliary atresia.

84. True. (False-positive studies can occur in cholestasis and at very high bilirubin levels.)

85. True or false: Renal excretion cannot be reliably distinguished from bowel activity on IDA images.

85. False. (Posterior images may help in distinguishing renal from bowel activity.)

86. True or false: Following intravenous administration of sincalide, contractile response of the gallbladder can be expected after approximately 60 minutes.

86. False. (The true time is within 10 minutes.)

87. In liver transplant patients, is hepatobiliary scintigraphy helpful in differentiating rejection and cholestasis?

87. No, the two are similar scintigraphically, with prolonged tracer retention and poor tracer clearance.

88. Following liver transplantation, the most common site for a biliary leak is __________.

88. the anastomotic site

89. Good hepatic uptake and persistent nonvisualization of the common bile duct, along with nonvisualization of the intestine, suggest __________.

89. acute common bile duct obstruction

90. Nonvisualization of the gallbladder on scintigrams in the presence of a normal gallbladder can occur in __________, __________, and __________.

90. postprandial patients; patients fasting longer than 24 hours; patients on parenteral nutrition

91. IDA is a structural analog of __________.

91. lidocaine

92. Following liver transplantation, the most common postoperative complication detected by a biliary scintigram is __________.

92. biliary leak

93. True or false: A bolus injection of sincalide is preferable to infusion over 5 to 10 minutes to obtain an accurate estimate of gallbladder ejection fraction.

93. False. (Rapid administration of cholecystokinin [CCK] may induce gallbladder spasm and thereby impede gallbladder contraction.)

94. True or false: The Kasai procedure is most successful when performed before the patient is 2 months of age.

94. True. (In untreated biliary atresia, progressive hepatic injury leads to cirrhosis and hence poor response to delayed intervention.)

95. True or false: Prolonged tracer uptake and clearance are typical of Dubin–Johnson syndrome.

95. False. (Hepatic uptake is prompt, as the extraction function is intact, but the excretion of organic ions into the bile is impaired; therefore, delayed clearance is characteristic.)

96. True or false: A choledochal cyst often remains as a persistent cold defect in the hepatobiliary scintigraphy.

96. False. (Although these cysts may initially appear as cold defects, they fill in slowly and rarely remain cold throughout the study.)

97. True or false: Choledochal cysts usually respond to cholecystokinin (CCK).

97. False. (A choledocal cyst is just a dilatation of the extrahepatic biliary tree, with no contractible elements.)

98. True or false: Intervention with morphine sulfate is contraindicated in patients with delayed gallbladder visualization.

98. False. (Morphine causes contraction of the sphincter of Oddi with increased pressure in the biliary tree, thus facilitating the entrance of the radiotracer into the cystic duct, and so is a useful technique to hasten gallbladder visualization.)

99. True or false: In an elderly patient, the most common cause of a lower gastrointestinal bleed is colon carcinoma.

99. False. (Diverticulosis is the most common cause.)

100. The most reliable technique currently available to detect upper GI bleeding is __________.

100. upper GI endoscopy

101. True or false: Extravasated blood usually moves antegrade in the bowel lumen.

101. False. (It can move either retrograde or antegrade.)

102. The critical organ for the labeled RBC technique is __________.

102. the spleen

103. True or false: The tagged RBC technique is more sensitive than Tc-SC scanning for the detection of GI bleeding.

104. The preferred radionuclide technique for the detection of lower GI bleeding is __________.

105. True or false: Most Meckel's diverticula that become symptomatic do so during adolescence.

106. True or false: Gastric mucosa is found in approximately 50% of Meckel's diverticula.

107. True or false: More than 50% of bleeding Meckel's diverticula contain ectopic gastric mucosa.

108. Possible pharmacologic interventions that might improve the ability to detect ectopic gastric mucosa are the administration of __________, __________, or __________.

109. True or false: If a patient with inferior vena cava obstruction is injected in the antecubital fossa with ^{99m}Tc-SC intravenously, the patient will demonstrate a hot quadrate lobe.

110. True or false: Routine single-photon emission computed tomography (SPECT) imaging in liver–spleen scans yields higher sensitivity and specificity.

111. True or false: Albumin colloid is an alternative liver and spleen imaging agent.

112. Delayed biliary-to-bowel transit on a hepatic 2,6-dimethyliminodiacetic acid (HIDA) scan may be indicative of:

a) opiate effect
b) chronic cholecystitis
c) other inflammatory conditions in the abdomen
d) any of the above
e) none of the above

113. Total retention of IDA in the hepatic parenchyma over a 4-hour time period in an acutely ill patient is reflective of:

a) cystic duct obstruction
b) hepatic parenchymal disease
c) partial common duct obstruction
d) complete duct obstruction
e) none of the above

103. True. (Because of the prolonged imaging time available, intermittent bleeding can be more readily detected.)

104. labeled (in vitro) RBC study

105. False. (Most become symptomatic during early childhood.)

106. False. (Only 15–25% contain ectopic gastric mucosa.)

107. True.

108. pentagastrin; glucagons; cimetidine

109. False. (Superior vena cava obstruction can result in a hot quadrate lobe.)

110. False. (Sensitivity may be increased, but specificity suffers.)

111. True.

112. d, any of the above.

113. d, complete duct obstruction

For questions 114, 115, and 116, match the pharmacologic interventions with their clinical usages in HIDA scintigraphy: used for biliary atresia, used for biliary dyskinesis, given 20 to 30 minutes after ^{99m}Tc-IDA to speed the completion of a study for suspected acute cholecystitis.

114. Phenobarbital

115. Morphine

116. Sincalide

117. True or false: The iminodiacetic acid group of hepatobiliary radiopharmaceuticals is similar to bilirubin, in that they are conjugated in the liver.

118. Which of the following disorders is usually associated with an enhanced blood pool on a labeled RBC study of the liver?

a) Hemangioma
b) Hepatoma
c) Metastatic disease
d) Focal nodular hyperplasia
e) All of the above

119. The term "colloid shift" is generally associated with:

a) metastatic disease
b) hepatoma
c) cirrhosis
d) all of the above
e) none of the above

120. Space-occupying lesions of the liver that generally concentrate ^{67}Ga citrate include:

a) lymphoma
b) hepatoma
c) abscess
d) all of the above
e) none of the above

121. True or false: In vitro labeling of RBCs is more effective than the modified in vitro method.

122. The normal half-time of gastric emptying of a labeled solid meal is:

a) 30 to 45 minutes
b) 45 to 60 minutes
c) 75 to 90 minutes
d) 90 to 120 minutes
e) 120 to 180 minutes

114. biliary atresia

115. Morphine is given 20 to 30 minutes after ^{99m}Tc-IDA to speed the completion of study for suspected acute cholecystitis.

116. biliary dyskinesis

117. False.

118. a, hemangioma

119. c, cirrhosis

120. d, all of the above

121. True.

122. c, 75 to 90 minutes

123. Significantly prolonged esophageal transit is often associated with:

a) scleroderma
b) achalasia
c) diabetes mellitus
d) both A and B
e) none of the above

123. d, both scleroderma and achalasia

124. The current radiopharmaceutical of choice for confirming patency of LeVeen shunts (after intraperitoneal installation) is:

a) ^{99m}Tc-mercaptoacetyltriglycine (MAG3)
b) ^{111}In-DTPA
c) ^{99m}Tc–sulfur colloid
d) ^{99m}Tc–macroaggregated albumin (MAA)
e) none of the above

124. d, ^{99m}Tc–macroaggregated albumin (MAA)

125. True or false: Warthin tumors of the parotid gland generally show avid uptake of ^{99m}Tc-pertechnetate.

125. True.

126. What class of radiopharmaceuticals is used for cholescintigraphy?

126. ^{99m}Tc–iminodiacetic acid analogs.

127. What are the two agents approved by the Food and Drug Administration (FDA) for cholescintigraphy?

127. ^{99m}Tc-disofenin and ^{99m}Tc-mebrofenin.

128. Why is ^{99m}Tc-IDA called a bifunctional chelate?

128. One end of the molecule is polar and anionic, and it binds to ^{99m}Tc; the other end of the molecule is lipophilic and determines the molecule's biologic function.

129. How many IDA molecules does it take to chelate one ^{99m}Tc molecule?

129. Two.

130. What physiologic molecule does ^{99m}Tc-IDA most closely mimic?

130. Bilirubin.

131. Why is ^{99m}Tc-IDA not excreted by the kidneys?

131. It is protein bound in the circulation.

132. What is the main difference between the metabolism of ^{99m}Tc-IDA and that of bilirubin?

132. ^{99m}Tc-IDA is not conjugated.

133. Which factors determine the differential flow of excreted ^{99m}Tc-IDA into the gallbladder versus the duodenum?

133. The patency of the cystic ducts, the tone of the sphincter of Oddi, and intraluminal pressures.

134. What level of bilirubin is required to interfere with the quality of a ^{99m}Tc-mebrofenin or ^{99m}Tc-disofenin scan?

134. More than 20 to 30 mg/dL.

135. What is the alternative route of excretion of ^{99m}Tc-IDA with severe hepatocellular function?

135. Renal.

136. What percentage of a dose of ^{99m}Tc-mebrofenin is taken up by the liver?

136. 98%.

137. What percentage of a dose of ^{99m}Tc-disofenin is taken up by the liver?

137. 88%.

138. What is the biologic half-life of ^{99m}Tc-mebrofenin in the blood?

138. 17 minutes.

139. What is the biologic half-life of ^{99m}Tc-disofenin in the blood?

139. 19 minutes.

140. What percentage of a dose of ^{99m}Tc-mebrofenin is excreted by the kidneys?

140. Less than 1%.

141. What percentage of a dose of ^{99m}Tc-disofenin is excreted by the kidneys?

141. Less than 9%.

142. What is the critical organ for ^{99m}Tc-mebrofenin and ^{99m}Tc-disofenin, and what is its radiation dose?

142. The large bowel; 2.0 rad (20 mSv)/5 mCi (185 MBq).

143. How long should a patient fast before cholescintigraphy, and why?

143. 4 hours, to allow postprandial (CCK) levels to normalize.

144. What is the maximum time that a patient should fast before cholescintigraphy, and why?

144. 24 hours. After 24 hours, the gallbladder may be too tensely filled with bile to take up tracer.

145. How should patients in a prolonged fasting state be prepared before cholescintigraphy?

145. Injection of CCK or sincalide.

146. What causes the liver to be visualized at the same time as the spleen during the blood-flow phase of cholescintigraphy?

146. Arterialization of the flow to the liver, which may be seen in cirrhosis or involvement of the liver by tumor.

147. What type of collimator should be used for cholescintigraphy?

147. Low-energy, all-purpose parallel hole.

148. What type of computer acquisition should be used for cholescintigraphy?

148. 1-minute dynamic images for 60 minutes with an optional flow study (1-second images for 60 seconds).

149. How is hepatic clearance of the tracer assessed?

149. Compare the 5-minute image of liver uptake to the 1-minute blood pool image and look for clearing of the heart's blood pool by 5 minutes.

150. In a normal person, when is biliary excretion seen on cholescintigraphy?

150. At approximately 10 minutes.

151. How accurate is cholescintigraphy for anatomically sizing ducts?

151. It is not accurate and should not be used for this purpose.

152. In a normal fasting person, what proportion of excreted bile enters the gallbladder?

152. Two-thirds.

153. When is the normal gallbladder usually seen on cholescintigraphy?

153. On average at approximately 20 minutes and always within 60 minutes.

154. In a normal person, when is the bowel activity seen on cholescintigraphy?

154. 30 minutes; 10 to 20% of normal patients will have delayed biliary-to-bowel transit beyond 60 minutes.

155. How can one distinguish physiologically delayed biliary-to-bowel transit time from partial common bile duct obstruction on cholescintigraphy?

155. Obtain several images or administer sincalide.

156. What is sincalide?

156. Sincalide is a synthetic C-terminal octapeptide of CCK.

157. What are the major actions of sincalide?

157. Contraction of the gallbladder and relaxation of the sphincter of Oddi.

158. What is the half-time of sincalide in serum?

158. 2.5 minutes.

159. Which of the following are uses of sincalide for hepatobiliary scintigraphy?

a) To empty the gallbladder if NPO is greater than 24 hours.
b) Evaluation of sphincter of Oddi dysfunction.
c) Calculation of gallbladder ejection fraction.
d) All of the above.
e) None of the above.

159. d, all of the above

160. How should sincalide be administered if patient has been NPO for more than 24 hours?

160. 0.02 µg/kg over 30 minutes intravenously.

161. How long does one need to wait between administration of sincalide and dosing for cholescintigraphy?

161. At least 30 minutes.

162. How does prior sincalide administration affect the biliary-to-bowel transit time on cholescintigraphy?

162. Sincalide delays biliary-to-bowel transit time.

163. When performing cholescintigraphy, why should sincalide not be given after morphine?

163. Morphine counteracts the effects of sincalide.

164. How can one distinguish acute from chronic cholecystitis as a cause of nonvisualization of the gallbladder at 1 hour on cholescintigraphy?

164. Obtain delayed images and perform morphine augmentation.

165. What two scintigraphic findings on cholescintigraphy increase the likelihood that nonvisualization of the gallbladder is caused by acute cholecystitis?

165. Hyperemia in the gallbladder fossa on early phase images or a rim sign on later images.

166. What percentage of patients with acute cholecystitis have a rim sign on cholescintigraphy?

166. 25%.

167. What is the prognostic implication of a rim sign on cholescintigraphy?

167. It is associated with gallbladder gangrene and perforation.

168. How does morphine-augmented cholescintigraphy work?

168. Morphine increases the tone of the sphincter of Oddi, thereby raising common bile duct pressure and facilitating gallbladder filling if the cystic duct is patent.

169. How does one perform morphine-augmented cholescintigraphy?

169. If the gallbladder does not fill by 60 minutes on routine cholescintigraphy, give 0.04 µg/kg of morphine intravenously; if the gallbladder does not fill in an additional 30 minutes, the patient has cystic duct obstruction.

170. What is the major cause of a false-negative scan for acute cholecystitis on cholescintigraphy?

170. Acute acalculous cholecystitis.

171. How does one perform a gallbladder ejection fraction?

171. Administer sincalide 0.02 μg/kg intravenously over 60 minutes; a normal gallbladder ejection fraction is greater than 38%.

172. What patient preparation is required before cholescintigraphy for the diagnosis of congenital biliary atresia?

172. Phenobarbital 5 mg/kg for 5 days.

173. What are the specific scintigraphic findings of partial common bile duct obstruction on cholescintigraphy?

173. Common bile duct showing segmental narrowing, abrupt or gradual cutoff, filling defects, or activity that does not decrease on delayed images.

174. How does one identify a choledochal cyst on cholescintigraphy?

174. The cyst fills with tracer, although delayed images may be required to document filling.

175. Why do large cavernous hemangiomas have nonhomogeneous uptake on a ^{99m}Tc-RBC scan?

175. Because of thromboses within the hemangioma.

176. What is the positive predictive value of a positive ^{99m}Tc-RBC scan for cavernous hemangioma?

176. Greater than 99%.

177. What is the sensitivity of planar and SPECT imaging for the detection of cavernous hemangioma with ^{99m}Tc-RBCs?

177. Planar, 60 to 70%; SPECT, 85 to 90%.

178. How small a hemangioma can be seen with planar and SPECT ^{99m}Tc-RBC imaging?

178. Planar, 2 to 3 cm; SPECT, 1 to 1.5 cm.

179. What two tracers are available for liver–spleen scanning?

179. ^{99m}Tc–sulfur colloid and ^{99m}Tc–albumin colloid.

180. What is the blood clearance half-life of ^{99m}Tc–sulfur colloid?

180. 2 to 3 minutes.

181. What fractions of an intravenous dose of ^{99m}Tc–sulfur colloid localize in the liver, spleen, and bone marrow, respectively?

181. 85%; 10%; 5%.

182. What cells in the liver take up ^{99m}Tc–sulfur colloid?

182. The Kupffer cells.

183. How does an increased number of small particles affect the organ distribution of colloids?

183. Smaller particle sizes tend to localize in the marrow.

184. How does an increased number of large particles affect the organ distribution of colloids?

184. Larger particle sizes tend to localize in the liver.

185. What is a colloid shift, and what causes it?

185. A colloid shift is decreased uptake of colloid by the liver and increased uptake by the spleen, caused by liver dysfunction or a shift in blood flow (e.g., portal hypertension).

186. What is the main difference in the preparation of ^{99m}Tc–sulfur colloid versus ^{99m}Tc–albumin colloid?

186. ^{99m}Tc–sulfur colloid requires heating, while ^{99m}Tc–albumin colloid does not.

187. What is the typical appearance of a focal nodular hyperplasia (FNH) of the liver on ^{99m}Tc–sulfur colloid liver–spleen scanning?

187. One-third of the cases demonstrate increased activity. (One-third demonstrate normal activity, and one-third are photopenic.)

188. What is the typical appearance of an adenoma of the liver on ^{99m}Tc–sulfur colloid liver–spleen scanning?

188. Photopenic.

189. What is the typical appearance of a malignant lesion of the liver on ^{99m}Tc–sulfur colloid liver–spleen scanning?

189. Cold lesion.

190. Which of the following is true regarding hepatobiliary imaging of liver lesions?

a) Increased flow, prompt uptake, and delayed clearance represents FNH.
b) Normal flow with no uptake indicates adenoma.
c) Increased flow, delayed uptake (filling in), and clearance indicate malignancy.
d) All of the above.
e) None of the above.

190. d, all of the above.

191. What conditions might result in photopenic defects on ^{99m}Tc–sulfur colloid images and increased activity on ^{67}Ga images?

191. Hepatocellular carcinoma and liver abscess.

192. What are the characteristics of hepatic hemangioma on a ^{99m}Tc-RBC study?

192. Decreased perfusion, increased blood pool activity.

193. How does radiotherapy affect liver uptake of ^{99m}Tc–sulfur colloid?

193. It causes rectangular defects.

194. What is the typical cause of a hot quadrate lobe of the liver on ^{99m}Tc–sulfur colloid imaging?

194. Superior vena cava obstruction.

195. What is the typical cause of a hot caudate lobe of the liver on ^{99m}Tc–sulfur colloid imaging?

195. Budd–Chiari

196. What size of liver lesions can be reliably detected on planar images of a ^{99m}Tc–sulfur colloid liver–spleen scan?

196. 2 to 3 cm.

197. What size of liver lesions can be reliably detected on SPECT images of a ^{99m}Tc–sulfur colloid liver–spleen scan?

197. 1 to 1.5 cm.

198. Which agent can be used to image the spleen specifically, with minimal liver uptake?

198. ^{99m}Tc–heat-damaged RBCs.

199. (▶Fig. 9.1)

Choose the next best step in management:
a) digital exam for rectal bleed
b) angiography for rectal bleed
c) CT abdomen and pelvis with IV contrast
d) liver function test for persistent blood pool

199. c, see photopenic defects in liver, diagnosis of metastatic disease on further cross-sectional imaging.

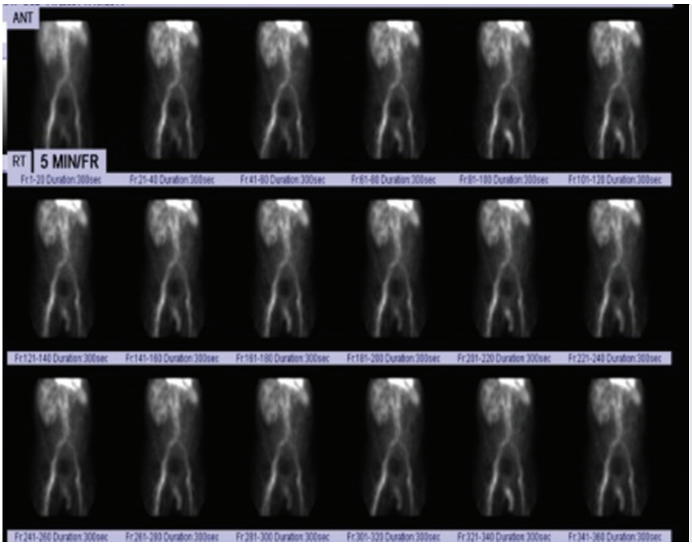

Fig. 9.1

200. (▶Fig. 9.2)

The findings on this scan are:

a) positive for GI bleed
b) negative for GI bleed
c) negative GI bleed with incidental finding of abdominal aortic aneurysm
d) positive for Meckel's diverticulum

200. c, negative GI bleed with incidental finding of abdominal aortic aneurysm.

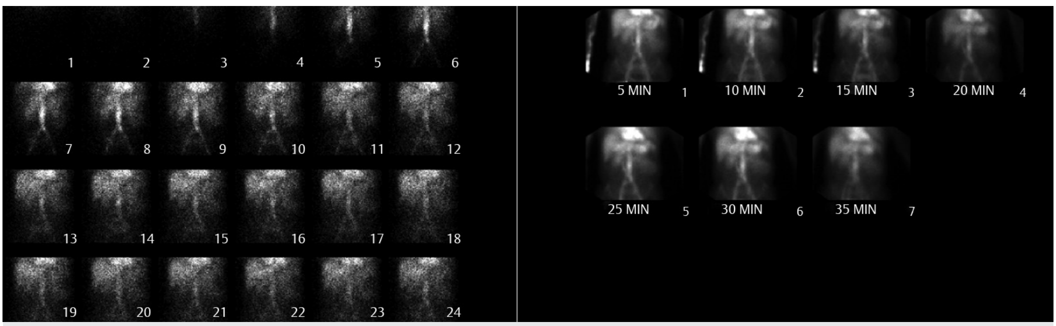

Fig. 9.2

201. Hepatobiliary scan of a patient who is s/p cholecystectomy (▶Fig. 9.3).

The findings are compatible with:

a) erroneous history of cholecystectomy
b) bile leak
c) rim sign
d) none of the above

201. b, bile leak

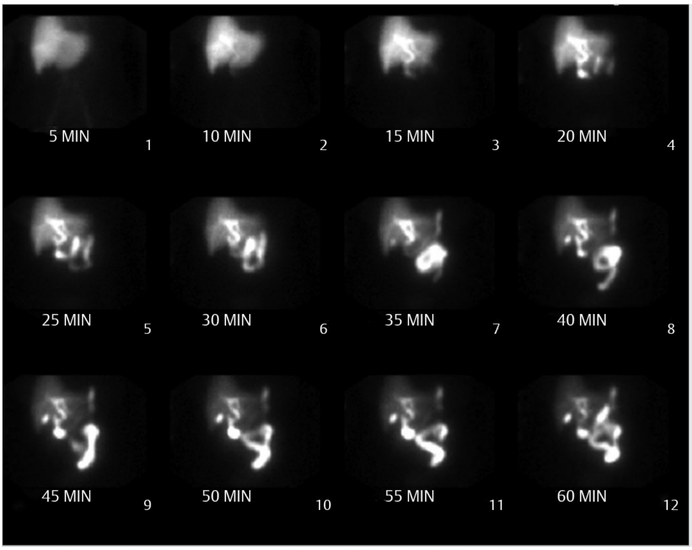

Fig. 9.3

202. What is the scan observed here (▶Fig. 9.4)?

a) Liver spleen scan (Tc-SC)
b) Bone scan (Tc-MDP)
c) Tagged WBC scan (In-WBC)
d) None of the above

202. a, liver spleen scan (Tc-SC) with colloid shift

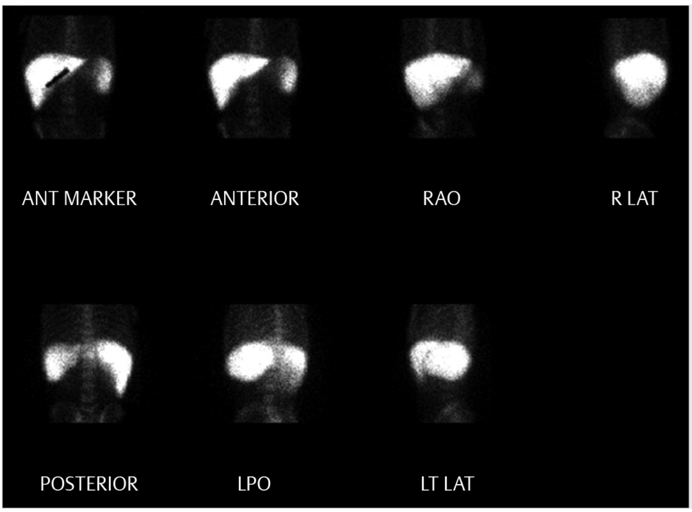

Fig. 9.4

203. What is the most likely cause of the findings in this study (▶Fig. 9.5; ▶Table 9.1)?

a) Diabetes
b) IBD
c) Cystic duct obstruction
d) *H. Pylori*

203. a, diabetes, finding is delayed gastric emptying (gastroparesis)

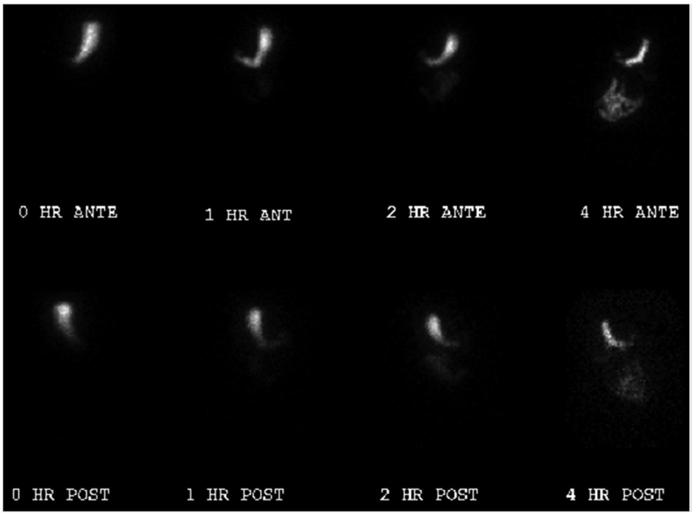

Fig. 9.5

Table 9.1

Data				
Image timer (h)	0	1	2	4
Clock time of acquisition (h:min)	9:30	10:30	11:30	13:30
Time diff (h) (x)	0.00	1.00	2.00	4.00
Decay factor	1.000	0.891	0.794	0.630
Anterior ROI counts	38,430	37,509	28,407	12,067
Posterior ROI counts	24,310	16,013	10,532	3,603
Geometric mean	30,565	24,508	17,297	6,594
Decay corrected geometric mean (y)	30,565	27,508	21,792	10,466
% retention	100%	90%	71%	34%

204. What is the pharmaceutical needed for this study and what does it do (▶Fig. 9.6a–c)?

a) Morphine; sphincter of Oddi constriction
b) CCK, gallbladder contraction
c) Morphine, gallbladder contraction
d) CCK, sphincter of Oddi constriction

204. b, CCK, gallbladder contraction

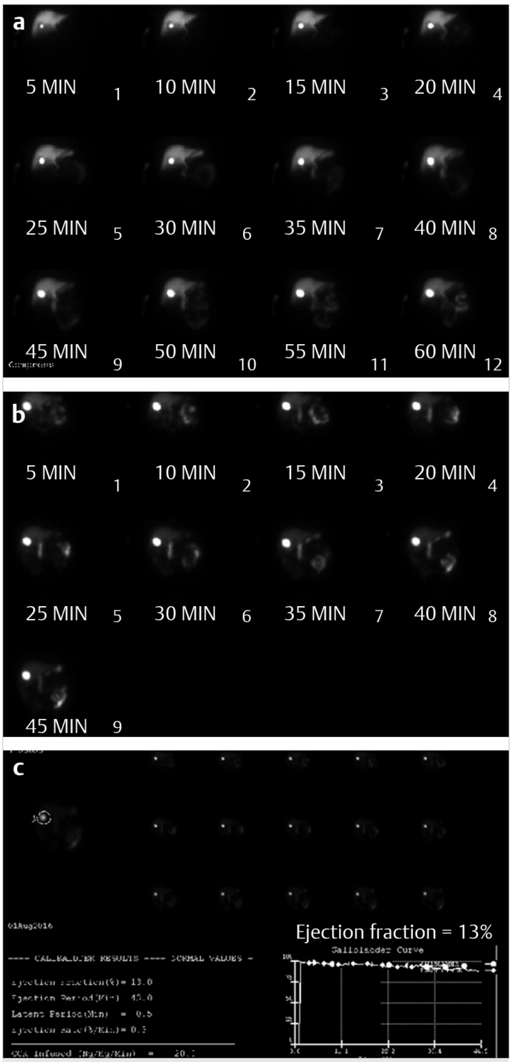

Fig. 9.6

205. What is the next best step after this 1-hour study (▶ Fig. 9.7)?

a) Delayed imaging
b) Morphine administration
c) CCK administration
d) End exam

206. What is the next best step after this 1-hour study (▶ Fig. 9.8)?

a) End study
b) Continue imaging
c) Give morphine
d) None of the above

205. a, delayed imaging. There is no bowel visualized so morphine cannot be given.

206. b, continue imaging. Although the gallbladder is seen, there is no bowel visualized. Imaging should be continued to exclude any biliary obstruction.

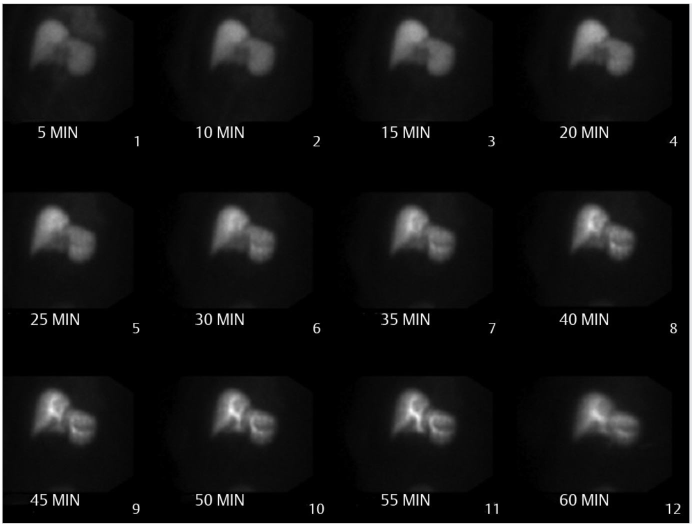

Fig. 9.7

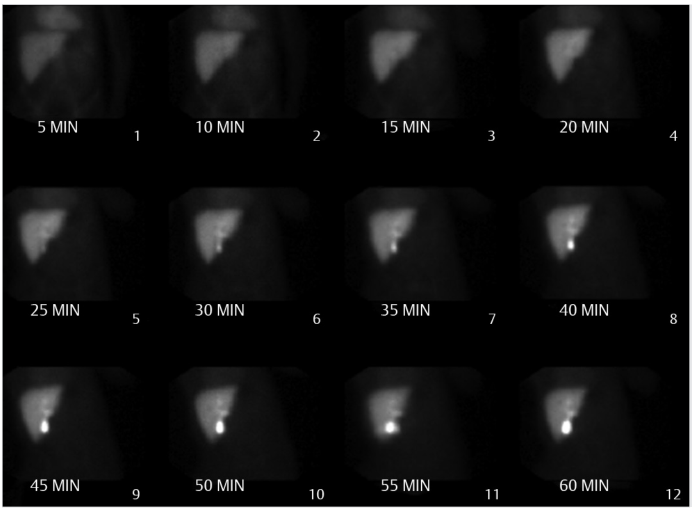

Fig. 9.8

207. What study is this and what are the findings (▶Fig. 9.9a, b)?

a) Bleeding scan, negative for GI bleed
b) Bleeding scan, positive for GI bleed
c) Positive Meckel’s scan
d) Negative Meckel’s scan

207. d, negative Meckel’s scan

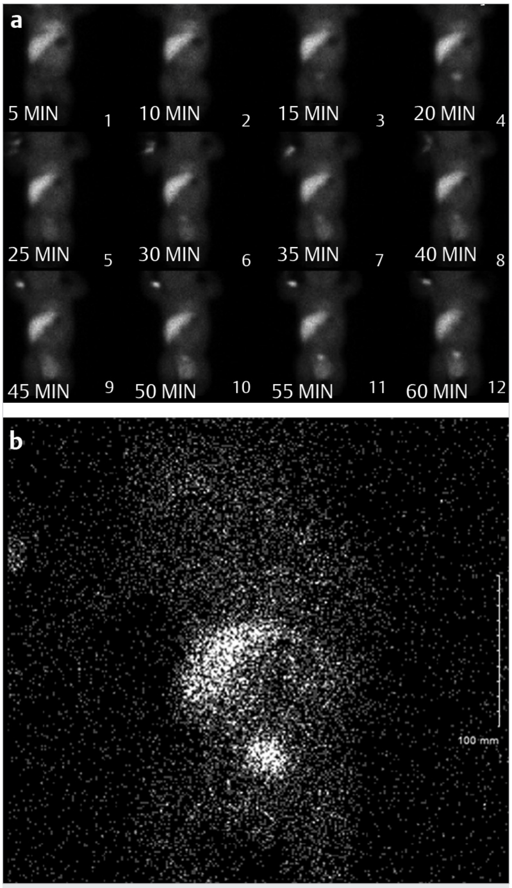

Fig. 9.9

208. What is the finding of this study (▶Fig. 9.10)?

a) Free pertechnetate
b) Bleeding in the descending/sigmoid colon
c) Positive Meckel's diverticulum
d) None of the above

208. b, bleed in the descending/sigmoid colon

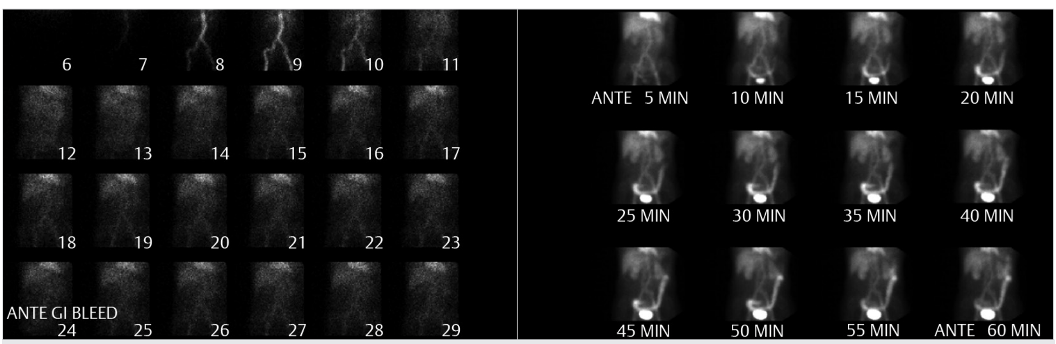

Fig. 9.10

209. What is a common sign/symptom in a pediatric patient with this finding (▶Fig. 9.11)?

a) Respiratory distress
b) Jaundice
c) Blood in stool
d) None of the above

209. a, respiratory distress from gastro-esophageal reflux

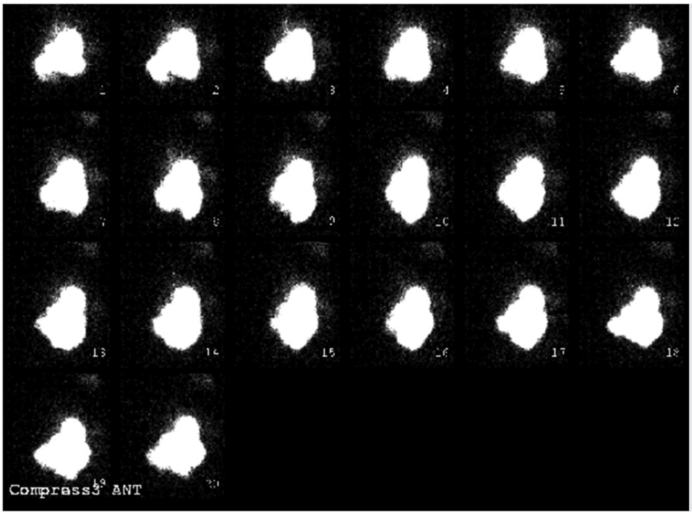

Fig. 9.11

10 Genitourinary

Questions

1. A currently used scintigraphic radiopharmaceutical that is excreted by the kidneys and measures effective renal plasma flow (ERPF) is __________.
2. To perform a flow study with a ^{99m}Tc-labeled radiopharmaceutical, one must inject __________.
3. The scintigraphic renal imaging agent that is primarily filtered and may be used to determine the glomerular filtration rate (GFR) is __________.
4. Scintigraphic renal agents that are used to assess the appearance of the renal parenchyma include __________.
5. The scintigraphic renal cortical imaging agent that also demonstrates the collecting system on the early images is __________.
6. Compared with ^{99m}Tc-GHA, the renal transit time of ^{99m}Tc-DMSA is __________.
7. The percentage of ^{99m}Tc-GHA retained by the kidneys is approximately __________.
8. The scintigraphic renal cortical imaging agent that reaches the highest concentration in the cortex (42% of the injected dose) is __________.
9. Of the most commonly used renal imaging agents, the one that gives the highest radiation dose to the kidneys is __________.
10. If a flow study and cortical imaging are to be performed, one should choose __________, because of the lower cortical radiation dose.
11. A radiopharmaceutical that is usually taken up by a suspected renal abscess is __________.
12. The kidneys are not normally well visualized on a ^{67}Ga-citrate scan after what span of time?

Answers

1. ^{99m}Tc-mercaptoacetyltriglycine (MAG3)
2. 5 to 15 mCi (185–555 MBq) as a bolus with rapid-sequence scintiphotos
3. ^{99m}Tc–diethylenetriaminepentaacetic acid (DTPA)
4. ^{99m}Tc–dimercaptosuccinic acid (DMSA) and ^{99m}Tc-glucoheptonate (GHA)
5. ^{99m}Tc-GHA
6. longer
7. 15%
8. ^{99m}Tc-DMSA
9. ^{99m}Tc-DMSA
10. ^{99m}Tc-GHA
11. ^{67}Ga-citrate
12. 24 hours.

13. The kidneys receive approximately what percentage of cardiac output?
14. The normal adult GFR is __________.
15. The normal adult renal blood flow is __________.
16. The normal adult renal plasma flow is __________.
17. The renal blood vessel that carries blood directly away from the glomerulus is called the __________.
18. Which portion of the greater renogram curve is most affected by dehydration?
19. Which portion of the renogram curve is most affected by acute obstruction?
20. When the percent function is determined, which portion of the radio-renogram curve is used?
21. What nonradioactive pharmaceutical is often administered to distinguish an obstructed dilated collection system from a nonobstructed dilated collection system during radiorenography?
22. In a nonobstructed kidney, the washout half-time on a post-Lasix renogram is less than __________ minutes.
23. In an obstructed kidney, the washout half-time on a post-Lasix renogram is generally greater than __________ minutes.
24. When the renogram data are processed, the background regions of interest are usually placed __________.
25. In children, the most common site of renal obstruction is at the __________.
26. In adults, the most common site of renal obstruction is at the __________.
27. Is an agent more likely to be filtered or secreted if it is highly protein bound?
28. What substance traditionally has been used to determine the GFR by non–nuclear medicine techniques?
29. The simplest way to reduce the radiation exposure to the bladder after a radionuclide renal study is by __________.
30. By definition, the filtration fraction is the ratio of __________.
31. On a normal renal flow study, the kidneys should be visualized __________.

13. 25%.
14. 125 mL/minute
15. 1,250 mL/minute
16. 700 mL/minute
17. efferent arteriole
18. Transit.
19. Excretion.
20. Uptake.
21. Furosemide (Lasix).
22. 10
23. 20
24. inferolateral to the kidneys
25. ureteropelvic junction
26. ureterovesical junction
27. Secreted.
28. Inulin.
29. having the patient void
30. the GFR to renal plasma flow
31. within 2 to 3 seconds of visualization of the adjacent aorta

32. During the course of a renal radionuclide study, a rising background curve can be most commonly seen when __________.

33. The two main pathologic processes that cause renal artery stenosis are __________.

34. The mechanism of action of captopril is __________.

35. In captopril renography of a patient with renal artery stenosis, what parameter of renal function is most affected on the postcaptopril study, and in what way?

36. On a renal flow study, the liver is visualized after the kidneys because __________.

37. What is the scintigraphic appearance of a lymphocele?

38. What is thought to be the cause of lymphocele formation?

39. The scintigraphic appearance of a hypertrophied column of Bertin is __________.

40. In kidneys with a duplicated collecting system, obstruction more commonly occurs in __________.

41. The most common abnormality of fusion involving the kidneys is __________.

42. At what anatomic location do dromedary humps occur?

43. On normal renal scintigraphy, the renal pelvis and collection system should be visualized initially at __________ minutes.

44. True statements regarding relative contribution of each kidney include which of the following?

a) Value of 40% or less in one kidney should be considered abnormal.
b) The renal function is normal only when there is equal contribution of each kidney.
c) Differential renal function 45–55% is normal.
d) The split renal function is assessed after the blood flow phase and before the excretory phase (1–3 minutes after the injection).

32. the dose is infiltrated

33. fibromuscular dysplasia and atherosclerotic disease

34. blockade of the conversion of angiotensin I to angiotensin II

35. The GFR. It is reduced.

36. the majority of blood supply to the liver is via the hepatic portal system, not the arterial

37. Photopenic area adjacent to the transplanted kidney.

38. Ligation or disruption of regional lymphatic vessels.

39. an area of tissue with normal function, similar to the surrounding renal parenchyma

40. the upper pole collecting system, the ureter of which tends to enter the bladder ectopically (Weigert–Meyer rule)

41. horseshoe kidney

42. The lateral margin of the left kidney.

43. 3 to 6 minutes

44. a, c, and d

45.	The patient preparation for a nuclear medicine renal study should include __________.	**45.**	hydration, and emptying of the bladder
46.	If 1 month after transplant a patient who has received antirejection medications begins to have delayed excretion with relatively preserved perfusion, one should consider __________.	**46.**	cyclosporine toxicity
47.	When a renogram is performed on a posttransplant patient, the gamma camera is typically placed __________.	**47.**	anteriorly over the pelvic transplant site
48.	The typical scintigraphic appearance of a renal cyst is __________.	**48.**	a round photopenic area within normal renal parenchyma
49.	On a renal parenchymal study, a wedge-shaped defect extending to the periphery of an involved kidney may represent __________.	**49.**	an infarct or pyelonephritis
50.	In the evaluation of early posttransplant renograms, a pattern of normal uptake and delayed, but not absent, excretion is most consistent with what diagnosis?	**50.**	Acute tubular necrosis.
51.	The etiology of hyperacute renal transplant rejection is __________.	**51.**	preformed antibodies in the recipient causing renal vasculature thrombosis
52.	The time frame for hyperacute renal transplant rejection is __________.	**52.**	within 24 hours of transplant
53.	The type of renal transplant rejection that occurs several days to several weeks after the transplant is termed __________.	**53.**	acute rejection
54.	^{99m}Tc-MAG3 scintigraphic findings consistent with acute renal transplant rejection are __________.	**54.**	delayed, decreased flow, delayed uptake, and cortical retention
55.	Is the perfusion to the transplanted kidney worse with acute tubular necrosis (ATN) or with rejection?	**55.**	With rejection.
56.	The type of renal transplant rejection that is predominantly mediated by cellular immune mechanisms is __________.	**56.**	chronic rejection
57.	Where are most sites of urine extravasation found in posttransplant patients?	**57.**	At the ureterovesical anastomosis.
58.	What diagnosis should be considered in a renal transplant patient when there is an area of photopenia near the kidney that progressively demonstrates increased uptake with time?	**58.**	Urinoma. (The bladder must first be excluded.)
59.	Approximately what percentage of adults with autosomal dominant polycystic kidney disease (ADPKD) have liver cysts?	**59.**	70 to 75%.
60.	What percentage of medullary sponge kidney disease is bilateral?	**60.**	75%.

61. Which disease is more life-threatening: infantile polycystic renal disease or medullary sponge kidney disease?

61. Infantile polycystic renal disease is typically bilateral and fatal.

62. At what vertebral levels are the kidneys usually located?

62. Upper poles at T11 and lower poles near L3.

63. Which kidney is more frequently ptotic?

63. The right kidney.

64. Which kidney is more frequently ectopic?

64. The left kidney.

65. The renal tumor common in patients with tuberous sclerosis is __________.

65. hamartoma (angiomyolipoma).

66. False-negative angiotensin converting enzyme (ACE) inhibitor renal scintigraphy could be due to which of the following?

a) Chronic ACE therapy
b) Baseline renal insufficiency
c) Renal artery stenosis more than 90% (insufficient compensation at baseline to allow detectable changes with ACE inhibitor)
d) None of the above

66. a, b, and c

67. False-positive captopril renal scintigraphy could be related to which of the following?

a) Poor hydration
b) Hypotension
c) Hydronephrosis
d) Patulous collecting system

67. a, b, c, d

68. What are the two main methods to perform radionuclide cystography?

68. Direct and indirect cystography.

69. Grade 1 reflux signifies __________.

69. urinary reflux into the ureter only

70. Grade __________ reflux occurs when there is reflux into a dilated ureter and renal pelvis.

70. 3

71. What radiopharmaceuticals are used to perform direct cystography?

71. ^{99m}Tc-DTPA, ^{99m}Tc-pertechnetate, and ^{99m}Tc–sulfur colloid.

72. Which is more sensitive for detecting reflux: a radionuclide cystogram or a contrast cystogram (voiding cystourethrogram [VCUG])?

72. A radionuclide cystogram.

73. Which radionuclide cystographic technique allows one to evaluate renal function also?

73. The indirect radionuclide cystogram.

74. Approximately what percentage of patients demonstrate reflux only during filling?

74. 20%.

75. What is the main disadvantage of the direct radionuclide cystogram technique?

75. It requires bladder catheterization.

76. True statements regarding radionuclide cystogram include which of the following?

a) It can be performed as part of routine dynamic renal scintigraphy done with ^{99m}Tc-MAG3.
b) Indirect radionuclide cystogram successfully detects reflux that occurs during bladder filling.
c) ^{99m}Tc-DTPA may be absorbed through the bladder wall.
d) False-negative results can occur with reflux confined to the distal ureter.

76. a and d

77. What position is a young child placed in when a radionuclide cystogram is performed?

77. Lying, with the camera positioned posteriorly.

78. What are the three phases of a direct radionuclide cystogram?

78. Filling, voiding, and postvoiding images.

79. What is the formula for calculating the average bladder capacity of a child?

79. (Child's age + 2) × 30 mL.

80. Residual urine volume can be determined after what radionuclide techniques?

80. After direct or indirect cystography and after a renal scan.

81. The anatomic anomaly often associated with testicular torsion is __________.

81. "bell clapper" anomaly

82. The radiopharmaceutical generally used for testicular scanning is __________.

82. ^{99m}Tc-pertechnetate

83. On static delayed images, acute testicular torsion appears as __________.

83. a photopenic defect surrounded by normal scrotal activity

84. A photopenic defect in the region of the testes surrounded by hyperemia of the scrotum is suggestive of (but not specific for) __________.

84. late torsion

85. The appearance of epididymitis/orchitis on scrotal scintigraphy is __________.

85. hyperemia of the involved epididymis/testicle, often with increased flow seen on the dynamic images as well

For questions 86 through 91, match the statement with the appropriate radiopharmaceutical by choosing among ^{99m}Tc-DTPA, ^{99m}Tc-glucoheptonate, ^{99m}Tc-DMSA, ^{99m}Tc-MAG3.

86. Early glomerular filtration and late parenchymal phase

86. ^{99m}Tc-glucoheptonate

87. No tubular component

87. ^{99m}Tc-DTPA

88. Actively secreted by tubules with no significant filtration

88. ^{99m}Tc-MAG3

89. More than 40% of the administered dose binds to the tubules

89. ^{99m}Tc-DMSA

90. Normal ERPF is between 400 and 500 mL/minute

90. ^{99m}Tc-MAG3

91. Associated with the lowest radiation dose to the kidneys

91. ^{99m}Tc-MAG3

92. True or false: Captopril acts by blocking the production of angiotensin I.

92. False.

93. True or false: Renal cell carcinoma generally shows increased concentration of glucoheptonate and DMSA compared with normal surrounding renal parenchyma.

93. False.

94. In renal transplant evaluation, ATN typically is associated with:

a) poor perfusion, slow but good uptake, slow progressive excretion
b) poor perfusion, poor uptake, slow progressive excretion
c) good perfusion, slow but good uptake, little or no excretion
d) good perfusion, good uptake, little or no excretion
e) none of the above

94. d, good perfusion, good uptake, little or no excretion

95. In renal transplant evaluation, chronic rejection typically is associated with:

a) poor perfusion, slow but good uptake, slow progressive excretion
b) poor perfusion, poor uptake, slow progressive excretion
c) good perfusion, slow but good uptake, little or no excretion
d) good perfusion, good uptake, little or no excretion
e) none of the above

95. b, poor perfusion, poor uptake, slow progressive excretion

96. Quantitative or semiquantitative determination of individual renal function can be achieved with:

a) ^{99m}Tc-MAG3
b) ^{99m}Tc-DTPA
c) ^{99m}Tc-DMSA
d) all of the above
e) none of the above

96. d, all of the above

97. True or false: Static "morphologic" images with glucoheptonate and DMSA are not as sensitive as urography or sonography in detecting pyelonephritis.

97. False.

98. An 81-year-old man with known exophytic mass in the right kidney underwent renal cortical imaging prior to radiation therapy (▶Fig. 10.1).

True statements regarding ^{99m}Tc-DMSA imaging include which of the following?

a) Dynamic and static images of the kidneys are performed.
b) Planar and SPECT images are performed at 2 to 3 hours after the injection.
c) Acquired with parallel collimator for differential calculation and pinhole collimator for cortical imaging.
d) Of the most commonly used renal imaging agents, ^{99m}Tc-DMSA gives least radiation dose to the kidneys.

Fig. 10.1

98. b and c

99. In acute pyelonephritis, DMSA imaging can demonstrate: (select all that apply)

a) single area of decreased renal cortical uptake with no evidence of volume loss
b) multiple unilateral or bilateral renal cortical defects
c) diffuse involvement of an entire kidney
d) single area of decreased renal cortical uptake with renal volume loss

99. a, b, and c

100. A 45-year-old man with acute kidney injury underwent ^{99m}Tc-MAG3 renal scintigraphy (▶Fig. 10.2).

Which of the following is true regarding the renogram images?
(Choose all that apply)

a) There is prompt bilateral renal cortical uptake.
b) There is marked delay in bilateral renal cortical transit.
c) There is persistent increased activity in the collecting system of both kidneys.
d) Study findings are consistent with ATN.

100. a, b, and d

Fig. 10.2

101. A 75-year-old woman with elevated serum creatinine underwent ^{99m}Tc-MAG3 renal scintigraphy (▶Fig. 10.3).

Which of the following is true regarding the interpretation of the study shown? (Choose all that apply)

a) There is moderate persistence of tracer in the bilateral renal cortex and prolonged cortical transit.
b) There is persistence of tracer concentration throughout both ureters.
c) Findings are most consistent with bilateral renal parenchymal disease associated with nephrolithiasis.
d) Findings are most consistent with bilateral renal parenchymal disease associated with neurogenic bladder.

101. a, b, and d

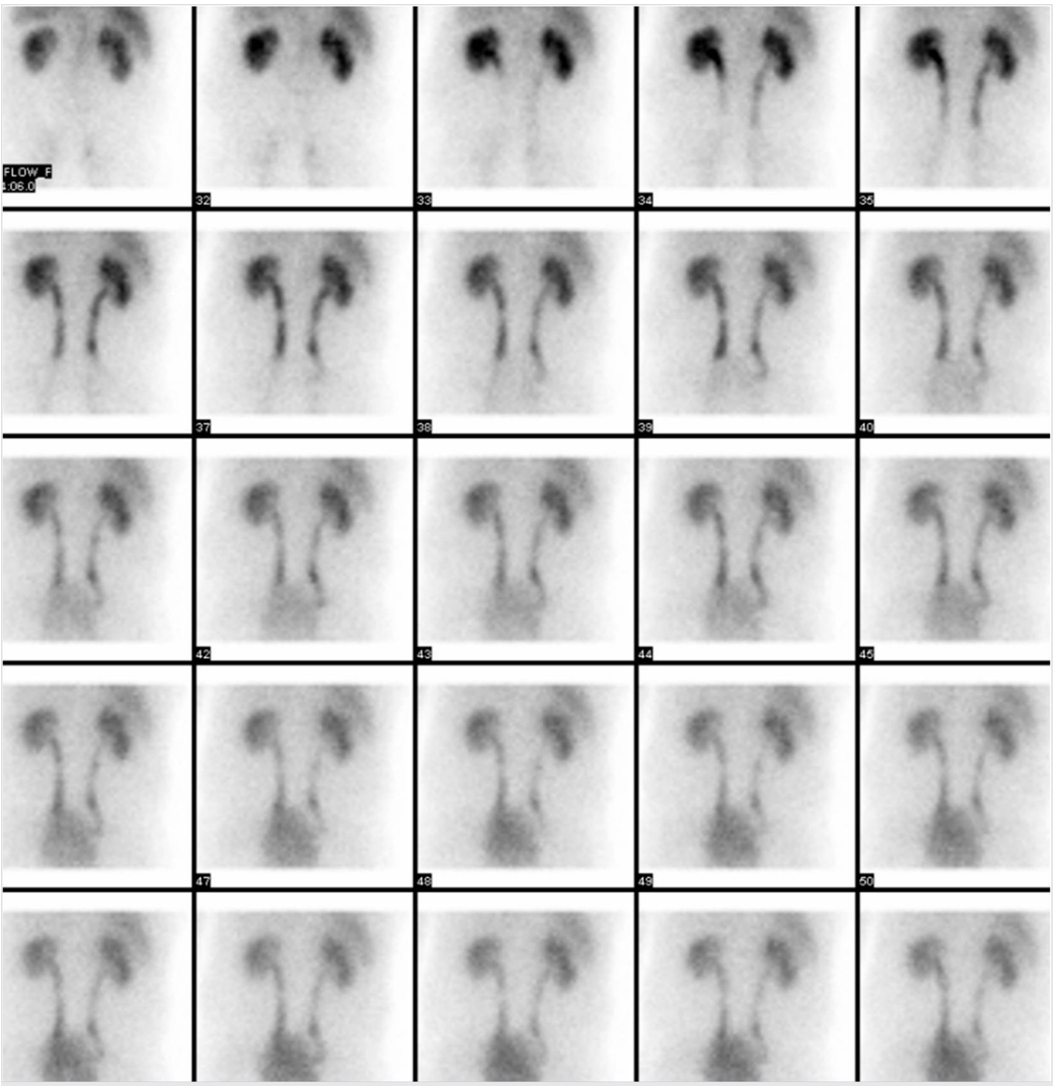

Fig. 10.3

102. A 35-year-old woman with history of congenital hydronephrosis underwent-^{99m}Tc-MAG3 renography with administration of diuretic (▶Fig. 10.4).

Which of the following factors affect the accuracy of diuresis renography? (Choose all that apply)

a) Dose of diuretic
b) Renal function
c) Level of hydration
d) Age of the patient

102. a, b, and c

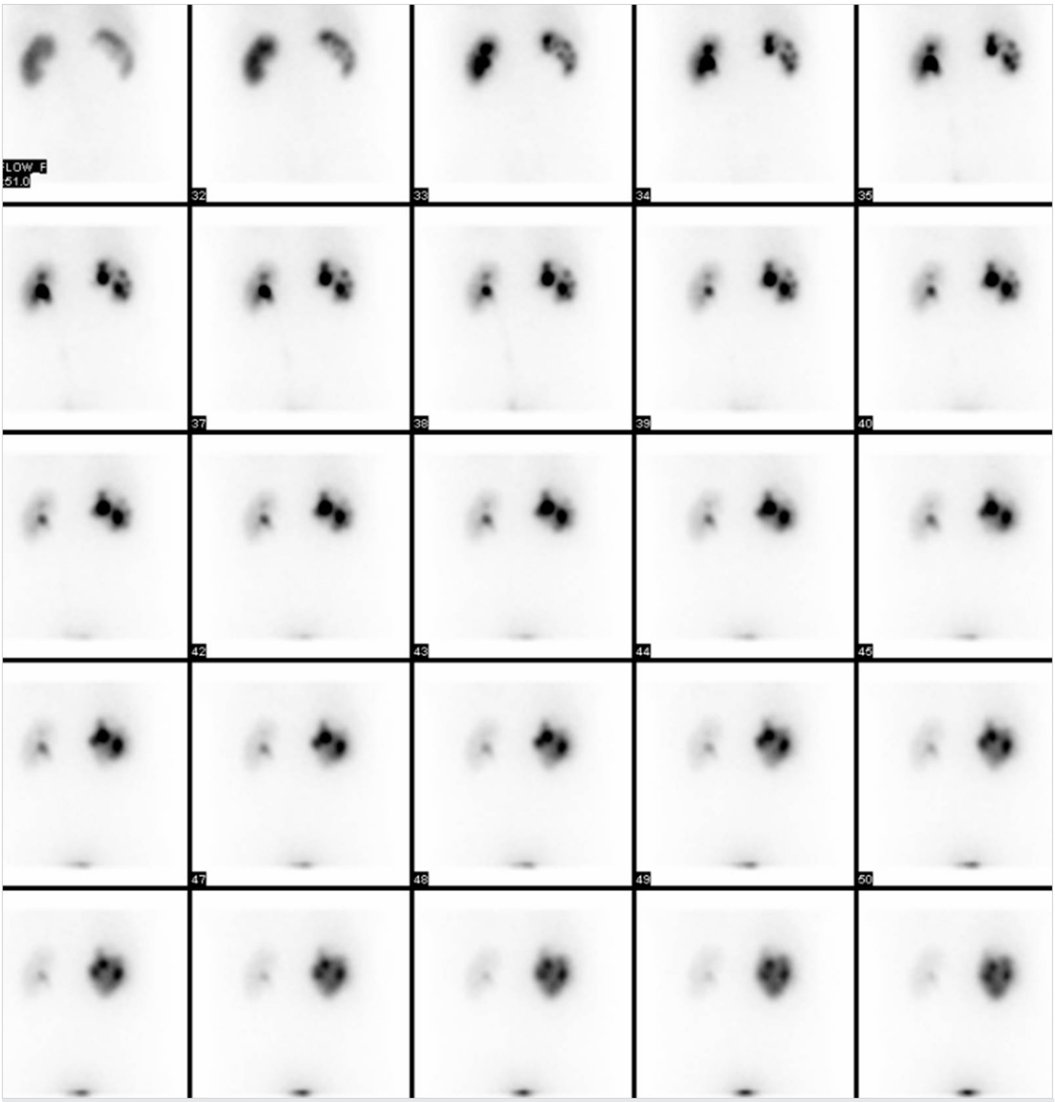

Fig. 10.4

103. Which of the following regarding furosemide renography is true? (Choose all that apply)

a) Dilated intrarenal collecting system can be due to obstruction or flaccid system.
b) Rapid tracer washout after furosemide administration indicates a flaccid system.
c) Good diuretic response excludes partial obstruction.
d) Diuretic renography is frequently performed to determine the functional significance of a known partial obstruction.

104. A 60-year-old woman underwent preoperative renal scintigraphy prior to renal transplant. Selected flow and renogram images from ^{99m}Tc-MAG3 study are shown below (▶Fig. 10.5).

Which of the following is (are) the most likely explanation of the scintigraphic findings on this examination?

a) Renal vein thrombosis
b) Renal artery stenosis
c) Polycystic kidney disease
d) Obstructive uropathy

103. a, b, and d

104. a, c

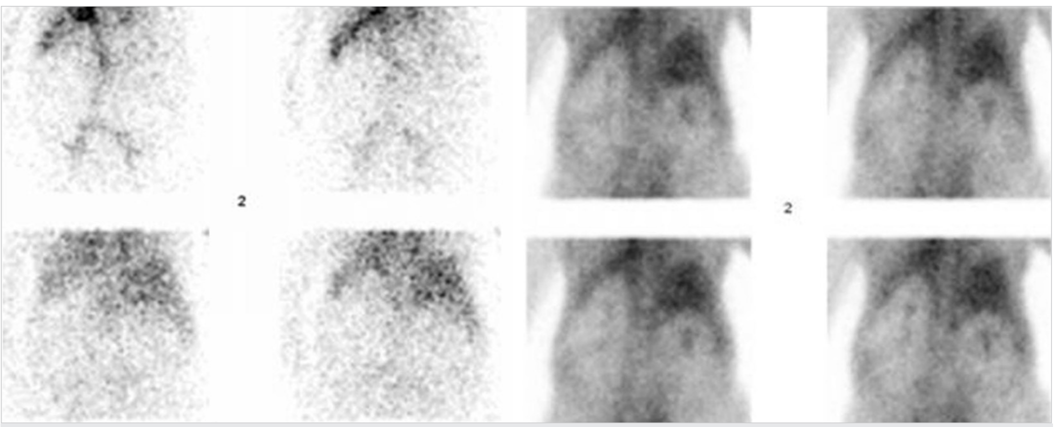

Fig. 10.5

105. True statements regarding renal transplant radionuclide imaging include which of the following?

(Select all that apply)

a) The gamma camera is typically placed anteriorly.
b) ^{99m}Tc-MAG3 is the most commonly employed tracer for imaging.
c) Planar imaging is usually sufficient.
d) Diuretics are used when collecting system obstruction is suspected.
e) All of the above.

105. e, all of the above

106. A 50-year-old man underwent renal scintigraphy 1 day following cadaveric kidney transplant. Flow and renogram images from the ^{99m}Tc-DTPA study are shown below (▶Fig. 10.6a, b).

This test demonstrates evidence for:

a) hyperacute renal transplant rejection
b) accelerated acute renal transplant rejection
c) acute renal transplant rejection
d) normal flow and function of the transplanted kidney

106. d

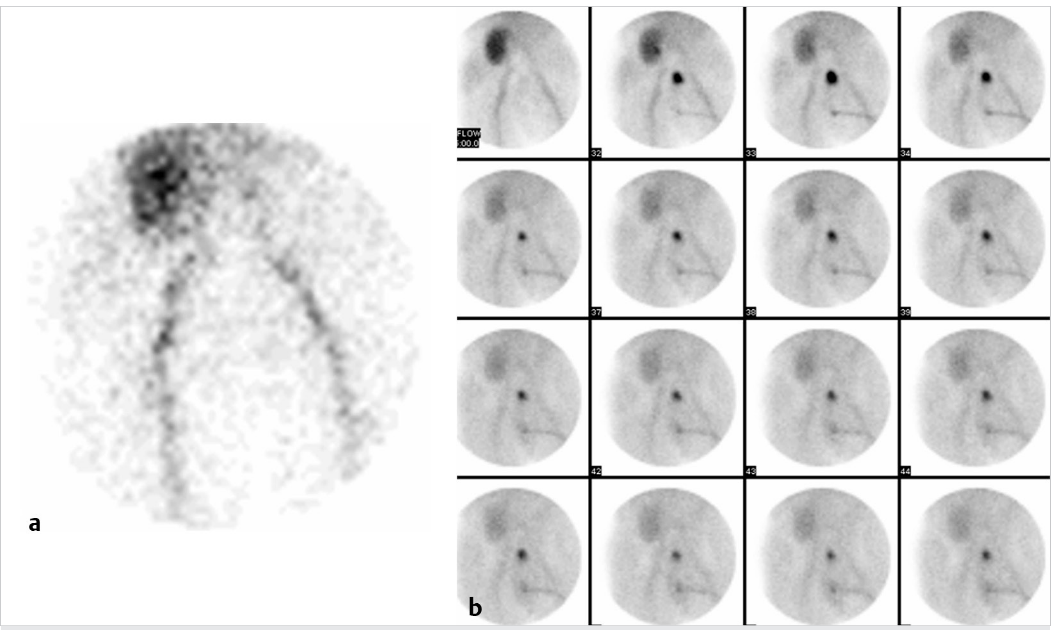

Fig. 10.6

107. A 50-year-old man with spike in the serum creatinine underwent ^{99m}Tc-DTPA renal scintigraphy 6 months following a cadaveric kidney transplant. Flow and functional images from the study are shown below (▶Fig. 10.7a, b).

This test demonstrates evidence for:
a) accelerated acute rejection
b) acute rejection
c) chronic renal transplant rejection
d) urinary leak

107. c

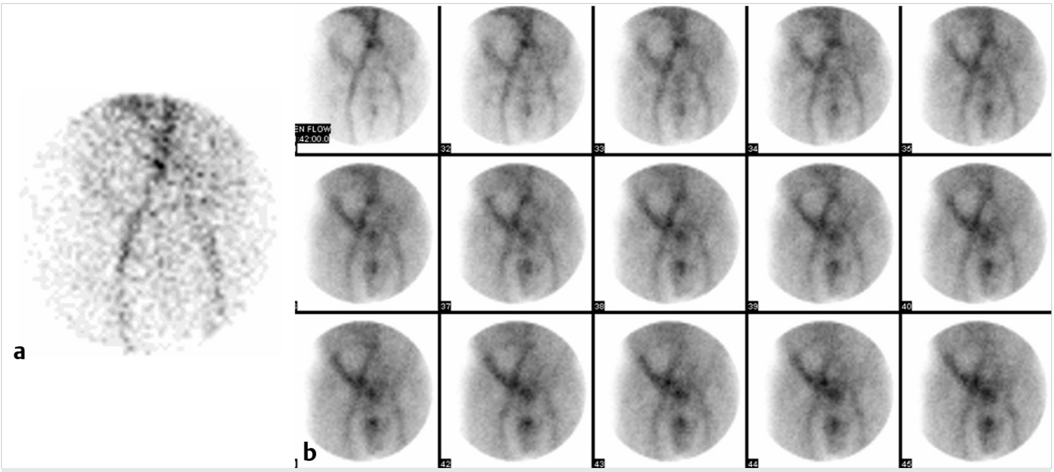

Fig. 10.7

108. A 72-year-old man with difficult to control hypertension underwent ^{99m}Tc-MAG3 ACE renography with captopril.

Baseline study
▶Fig. 10.8a
ACE inhibitor study
▶Fig. 10.8b
Based on the images, what is the probability of a renin-dependent renovascular hypertension in this patient?
a) Low probability (less than 10%)
b) Intermediate probability
c) High probability (more than 90%)
d) Nondiagnostic study

108. c

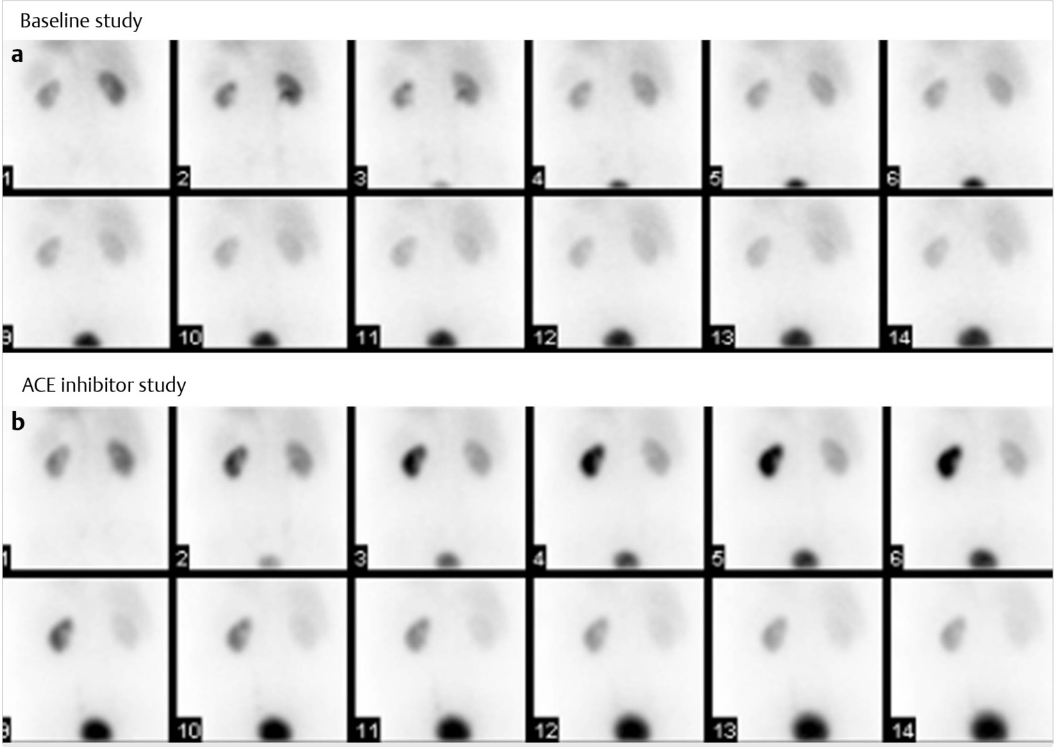

Fig. 10.8

109. Which of the following is (are) correct regarding captopril renal scan and high probability for renal vascular hypertension? (Select all that apply)

a) MAG3: Cortical retention (primary finding) and delayed time to peak
b) MAG3: Decreased differential renal function (less common) compared to the baseline study
c) DTPA: > Drop in renal function (primary finding)
d) DTPA: > 10% decrease in GFR; > 10% decrease in differential renal function
e) All of the above

110. A 65-year-old woman with right flank pain underwent ^{99m}Tc-MAG3renal imaging. Selected renogram images are shown below (▶Fig. 10.9).

The appearance of the right kidney could be associated with which of the following? (Choose all that apply)
a) Renal cell carcinoma
b) Renal lymphoma
c) Hypertrophied column of Bertin
d) Cyst

109. e, all of the above

110. a, b, and d

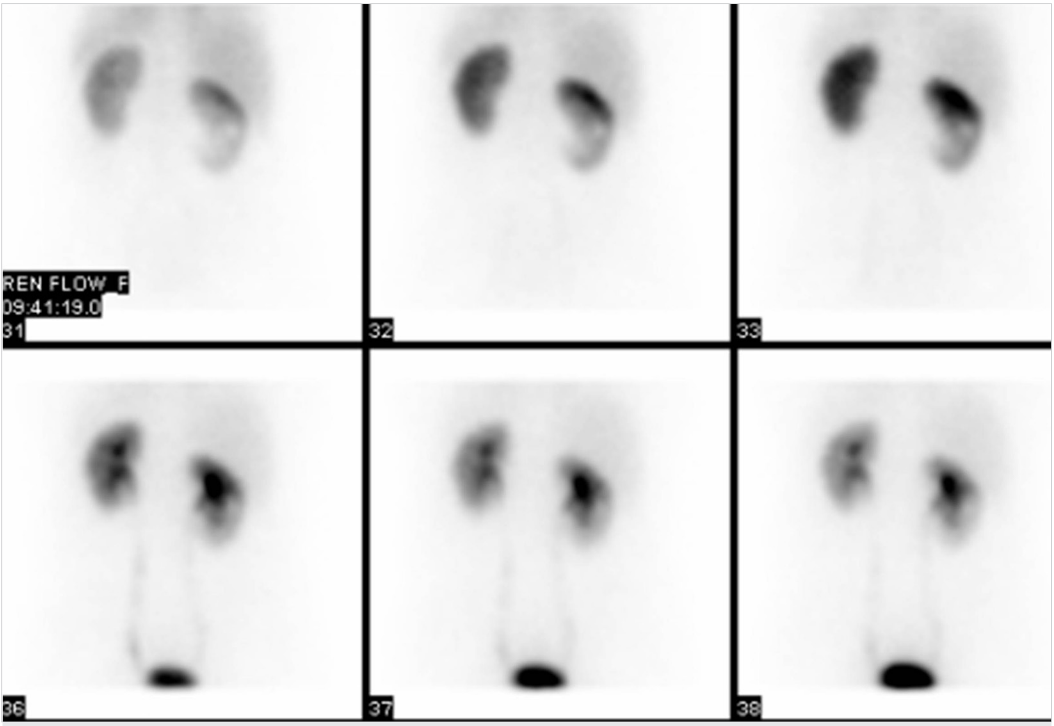

Fig. 10.9

111. A 19-year-old man with history of reducible left inguinal hernia and sudden onset of pain in the left scrotum underwent ^{99m}Tc-pertechnetate testicular scintigraphy. Flow and static images of the scrotal region are demonstrated (▶Fig. 10.10a, b).

The test findings are suspicious for:

a) left testicular abscess
b) acute left testicular torsion
c) delayed left testicular torsion
d) right-sided epididymitis

111. b

112. Flow, function, and delayed images suggest (▶Fig. 10.11a–c):

a) acute rejection
b) ATN
c) chronic rejection
d) leak

112. d

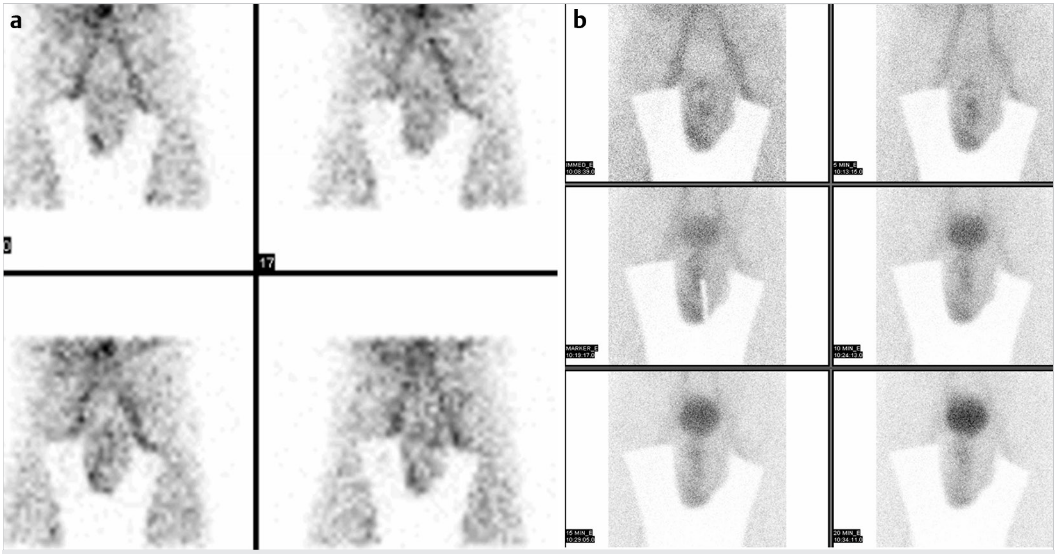

Fig. 10.10

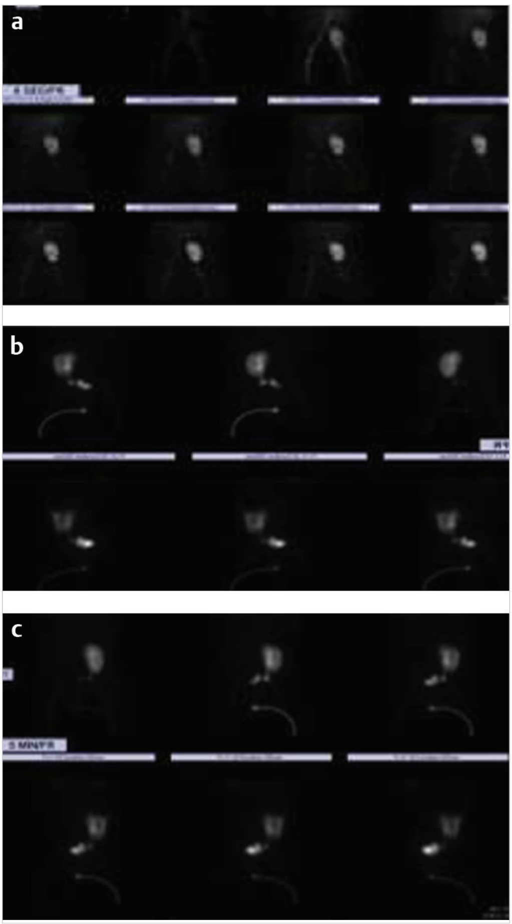

Fig. 10.11

11 Infection, Inflammation, and Oncology

Questions

1. Which element does ^{67}Ga most closely mimic in terms of biologic behavior?
2. How is ^{67}Ga produced?
3. How does ^{67}Ga decay?
4. What is the half-life of ^{67}Ga?
5. What are the energies of the principal photons of ^{67}Ga decay?
6. What photopeaks of ^{67}Ga are most commonly used for imaging?
7. To what serum protein does ^{67}Ga bind after injection?
8. Why does gallium not become incorporated into heme and other similar iron-containing compounds?
9. What percentage of a dose of ^{67}Ga is excreted by the kidneys in the first 24 hours after injection?
10. What is the biologic half-life of ^{67}Ga excretion beyond 24 hours after injection?
11. What is the major source of ^{67}Ga excretion beyond 24 hours after injection?
12. How does iron overload affect ^{67}Ga biodistribution?
13. What mechanisms cause ^{67}Ga uptake by tumors?
14. How does ^{67}Ga uptake differ between viable and necrotic tumors?
15. How does the dose of ^{67}Ga used for tumor detection differ in general from the dose used for inflammation detection?
16. What is the usual dose of ^{67}Ga for tumor detection?

Answers

1. Iron (Fe-III).
2. By cyclotron bombardment of ^{68}Zn.
3. By electron capture.
4. 78 hours.
5. 93, 185, 300, and 394 keV.
6. 93 and 185 keV.
7. Transferrin.
8. Incorporation of iron into heme requires the reduction of Fe from the +3 to the +2 oxidation state, but gallium cannot be reduced by the body to a +2 state.
9. 15 to 25%.
10. 25 days.
11. The gastrointestinal (GI) tract.
12. It saturates transferrin and causes less liver uptake and more renal excretion and bone uptake.
13. Increased vascular permeability of tumors, transferrin receptors on tumors, and increased concentration of iron-binding proteins in tumors
14. ^{67}Ga is taken up only by viable tumors, not by necrotic tumors.
15. A larger dose is given for tumor detection.
16. 10 mCi (370 MBq).

17. What is the critical organ for ^{67}Ga dosimetry, and what is its radiation-absorbed dose?

17. The large intestine, with a dose of 9 rad (90 mGy)/10 mCi (370 MBq).

18. Why is there great variation in the medical literature regarding the utility of ^{67}Ga for tumor detection?

18. Most of it was published before 1985 (using lower doses), and there was no single-photon emission computed tomography (SPECT).

19. How many photopeaks of ^{67}Ga should be utilized for tumor detection?

19. At least two and preferably three.

20. How many counts should be obtained for planar ^{67}Ga images for tumor detection?

20. At least 500,000 counts for routine whole body images, and at least 1 million counts for the evaluation of areas of previous disease.

21. When should images be obtained with ^{67}Ga for tumor detection?

21. Imaging should begin between 2 and 7 days after injection.

22. What is the advantage of performing sequential single-photon emission computed tomography (SPECT) examinations with ^{67}Ga images for tumor detection?

22. Sequential SPECT examinations help differentiate pathologic abdominal uptake from physiologic bowel localization.

23. How much time should elapse between treatment with chemotherapy and ^{67}Ga imaging to assess tumor response?

23. 3 to 6 weeks.

24. How can one differentiate between inflammation and tumor when there is ^{67}Ga uptake and hilar lymph nodes?

24. ^{201}Tl imaging will show uptake in tumor but not in inflammation.

25. How does normal spleen uptake of ^{67}Ga compare with normal liver uptake of ^{67}Ga?

25. Spleen uptake is less than that of the liver.

26. Which organs normally take up ^{67}Ga?

26. Liver, spleen, bone marrow, salivary glands, lacrimal glands, nasal mucosa, external genitalia, and female breast.

27. What physiologic condition results in markedly increased female breast uptake of ^{67}Ga?

27. Lactation.

28. What condition can cause increased salivary gland uptake of ^{67}Ga that is unrelated to tumor or infection?

28. Head and neck radiotherapy.

29. In children, what organ in the chest may show physiologic uptake of ^{67}Ga?

29. Thymus.

30. For how long is intense kidney uptake normal on the ^{67}Ga scan?

30. 24 hours.

31. What are the causes of faint liver uptake on ^{67}Ga imaging?

31. Competition for uptake by tumor, liver dysfunction, recent administration with chemotherapy (vincristine), iron overload, and increased renal clearance.

32. What are the causes of increased kidney uptake on ^{67}Ga imaging data that are not related to infection or tumor?

32. Hepatic or renal failure, recent chemotherapy (vincristine and Cytoxan), and recent transfusion.

33. True or false: Renal or perirenal uptake after 24 hours on a ^{67}Ga scan is abnormal.

33. True.

34. What are the indications for ^{67}Ga imaging in infections?

34. Spine lesions, splenic abscess, FUO (without recent surgery), lung infections, infection in cases of leukopenia, sarcoid, and low-grade chronic infections.

35. How long can uninfected surgical wounds have increased uptake of ^{67}Ga?

35. 1 to 2 weeks.

36. How does lymphangiography affect ^{67}Ga uptake?

36. It can cause diffusely increased lung uptake.

37. What kind of maneuver increases the sensitivity of ^{67}Ga to the detection of affected axillary lymph nodes?

37. Imaging patients with their arms raised.

38. Why are large tumor deposits sometimes missed on ^{67}Ga imaging?

38. The larger tumors commonly undergo necrosis and no longer take up ^{67}Ga.

39. What other scan improves the detection of tumors in the liver or spleen by ^{67}Ga?

39. Comparison with a sulfur colloid study to look for areas of decreased uptake on colloid scan that fill in with ^{67}Ga.

40. What is the complication of using progressive enemas and bowel preparations for ^{67}Ga imaging?

40. They can cause bowel inflammation that takes up ^{67}Ga.

41. What is the sensitivity of ^{67}Ga for detecting Hodgkin's lymphoma?

41. Approximately 90%.

42. What histologic types of Hodgkin's lymphoma have the highest and lowest sensitivities for detection by ^{67}Ga?

42. Highest: nodular sclerosing, mixed cellularity, and lymphocyte depleted; lowest: lymphocyte predominant.

43. What is the sensitivity of ^{67}Ga imaging for detecting high-grade non-Hodgkin's lymphomas?

43. Approximately 85 to 90%.

44. How does the sensitivity of ^{67}Ga to the low- and intermediate-grade non-Hodgkin's lymphomas compare with its sensitivity to the higher-grade non-Hodgkin's lymphomas?

44. The sensitivity of ^{67}Ga is less.

45. What is the main use of ^{67}Ga imaging in lymphoma?

45. To determine tumor viability after chemotherapy.

46. How is ^{67}Ga imaging used to evaluate tumor viability?

46. A pretherapy scan is needed to confirm gallium uptake; posttherapy uptake indicates a persistent viable tumor.

47. How is ^{67}Ga useful in diagnosing hepatomas?

47. It can be used to distinguish hepatomas from the regeneration nodules.

48. What percentage of hepatomas is gallium avid?

48. 90%.

49. What percentage of hepatomas shows uptake greater than that of the normal liver?

49. 50%.

50. What is the sensitivity of ^{67}Ga imaging for soft-tissue sarcomas?

50. 90 to 95%.

51. What is the characteristic lung uptake on a ^{67}Ga scan in pneumocystis carinii pneumonia (PCP)?

51. Diffuse intense bilateral uptake without nodal or parotid activity.

52. What element does ^{201}Tl mimic in the body?

52. Potassium.

53. How does ^{201}Tl decay?

53. By electron capture.

54. What are the photopeaks of ^{201}Tl?

54. A cluster of X-rays from 69 to 83 keV, and gamma (γ) rays at 135 and 167keV.

55. What percentage of a dose of ^{201}Tl goes to the heart?

55. 3 to 5%.

56. What is the critical organ for intravenous ^{201}Tl chloride, and what is the radiation absorbed dose?

56. The kidneys, with a dose of 3.6 rad (36 mGy)/mCi (37 MBq).

57. When should imaging begin after ^{201}Tl injection for tumor detection?

57. 10 to 30 minutes.

58. Does ^{201}Tl imaging correlate with the histologic grade of primary brain glial tumors?

58. Yes—the higher the uptake, the higher the tumor grade.

59. Does ^{201}Tl imaging differentiate brain tumor recurrence from radiation necrosis?

59. Yes—tumor recurrence shows uptake, while radiation necrosis shows no uptake.

60. How is ^{201}Tl imaging useful for evaluating intracranial lesions in patients with acquired immunodeficiency syndrome (AIDS)?

60. Uptake in the brain indicates lymphoma or some other malignancy; no uptake suggests an infectious cause.

61. How is ^{201}Tl imaging useful in the management of primary bone tumors?

61. It accurately detects the extent of involvement and predicts and assesses the response to chemotherapy.

62. What is the advantage of ^{201}Tl imaging over ^{131}I imaging for detecting thyroid cancer?

62. ^{201}Tl imaging does not require withdrawal of thyroid hormone treatment.

63. What is the main advantage of ^{131}I imaging over ^{201}Tl imaging for the detection of thyroid cancer?

63. ^{131}I imaging projects the potential usefulness of ^{131}I therapy.

64. In a patient with a history of thyroid cancer and a negative ^{131}I scan, when is a ^{201}Tl scan indicated?

64. When the serum thyroglobulin level is elevated.

65. How is ^{201}Tl imaging useful in the evaluation of Kaposi's sarcoma?

65. Kaposi's sarcoma is usually negative on gallium imaging but is positive on thallium imaging.

66. What is the half-life of ^{111}In?

66. 67 hours (2.8 days).

67. True or false: Indium is cyclotron produced and decays by electron capture, emitting gamma (γ) photons of 173 and 247 keV.

67. True.

68. What is the typical labeling efficiency of an ^{111}In white blood cell (WBC) scan?

68. 75 to 90%.

69. What is the target organ in an ^{111}In-WBC scan?

69. The spleen, approximately 15–20 rad (150–200 mGy).

70. Which of the following might not result in an optimal ^{111}In-WBC scan?

a) Careful handling.
b) Leukocyte count less than 5,000/ mm^3.
c) No abnormal morphology, clumping, or red blood cell (RBC) contamination after labeling.
d) Minimal time interval between blood withdrawal and reinfusion.
e) None of the above.

70. b. Leukocyte count less than 5,000/ mm^3.

71. True or false: There is concern that the low-energy conversion and auger electrons from ^{111}In may affect the WBCs and labeling efficiency.

71. True.

72. How can you recognize an ^{111}In-WBC scan?

72. The spleen is the most intense organ, followed by the liver and marrow. There is no intestinal or renal activity.

73. How is an ^{111}In-WBC scan obtained at 4 hours for evaluation of inflammatory bowel disease (IBD) different from the 24-hour images?

73. The lung activity seen on 4-hour images resolves on the 24-hour images.

74. When ^{111}In-WBC imaging is performed along with a ^{99m}Tc–sulfur colloid scan in evaluation of prosthetic infection, which of the following is true?

a) Sulfur colloid images are obtained first, followed by administration of ^{111}In-labeled WBC and delayed scan.
b) There is simultaneous dual isotope acquisition, using different energy windows.
c) Both of the above.

74. c. Both of the above.

75. What are some of the indications for an ^{111}In-WBC study?

75. Prosthetic infection, intra-abdominal infection, extremity osteomyelitis, inflammatory bowel disease (IBD), and acute infections.

76. True or false: An ^{111}In-WBC scan is limited for evaluation of spinal infections, with a 40% false-negative rate.

76. True.

77. What are some of the indications for a ^{99m}Tc-hexamethylpropyleneamineoxime (HMPAO) labeled WBC scan?

77. Evaluation of infections in pediatric population, IBD.

78. True or false: A ^{99m}Tc-HMPAO leukocyte scan preferentially labels granulocytes, and can be used to image acute infectious process.

78. True.

79. How does one recognize a ^{99m}Tc-HMPAO leukocyte scan?

79. Spleen activity is greater than liver activity, which is greater than marrow activity, as in an ^{111}In-WBC scan. However, there is intestinal and urinary activity on a ^{99m}Tc leukocyte scan. There is also diffuse mild lung uptake.

80. True or false: A ^{99m}Tc-HMPAO leukocyte study is obtained at 1 to 2 hours for IBD and 2 to 4 hours for extremity imaging.

80. True.

81. What imaging agent is available to image adrenal medullary tumors?

81. ^{123}I- or ^{131}I-MIBG (metaiodobenzylguanidine).

82. What are two advantages of using antibody fragments over the whole antibodies for immunoscintigraphy?

82. More rapid clearance and less antigenicity.

83. What is the name of the ^{99m}Tc-labeled radioimmunoscintigraphic agent for colon cancer?

83. Carcinoembryonic antigen (CEA) scan.

84. What is the name of an ^{111}In-labeled monoclonal antibody for imaging ovarian and colorectal carcinomas?

84. OncoScint.

85. What imaging agent is available to image adrenal cortical tumors?

85. ^{131}NP-59 (6-β-iodomethyl-19-norcholesterol).

86. What percentage of patients develop human antimouse antibody (HAMA) after injection with OncoScint?

86. 40%.

87. In what percentage of patients who develop HAMA do the antibodies eventually vanish?

87. 50%.

88. How can HAMA interfere with diagnostic tests?

88. It can cause false-positive assays of CEA and ^{125}Ca.

89. What are the humanized antibodies for radioimmunoscintigraphy?

89. Antibodies in which the variable region comes from mouse deoxyribonucleic acid (DNA) and the fixed region comes from human DNA.

90. True or false: NeutroSpec, a ^{99m}Tc-labeled intact murine immunoglobulin M (IgM) monoclonal antibody against human CD15 (fanolesomab) that can be utilized for appendicitis, is withdrawn and no longer available.

90. True.

91. True or false: LeukoScan, a ^{99m}Tc-labeled murine monoclonal immunoglobulin G (IgG) antibody Fab to NCA-90 of granulocytes, is utilized in Europe and Australia, but it is not available within the United States.

91. True.

92. Which of the following are commercially available within the United States?

a) OncoScint (^{111}In murine anti-TAG-72 [tumor-associated glycoprotein 72] IgG).
b) Verluma (^{99m}Tc murine anti-EGP-1 Fab).
c) Carcinoembryonic antigen (CEA) scan (^{99m}Tc murine anti-CEA Fab).
d) All of the above.
e) None of the above.

92. e. None of the above.

93. What is a ProstaScint study?

93. ProstaScint (capromab pendetide) is an ^{111}In-labeled murine immunoglobulin G (IgG) monoclonal antibody directed at prostate-specific membrane antigen (PSMA).

94. Which of the following is true regarding a ProstaScint study?

a) It is indicated for patients with clinically localized prostate cancer who are at high risk for metastases.
b) It is indicated in cases in which there is a high clinical suspicion of occult recurrent or residual prostate cancer.
c) There is a steep learning curve for interpretation of the scan.
d) It requires either a correlative blood pool scan or SPECT-CT.
e) All of the above.

94. e. All of the above.

95. What agent is available for imaging tumors having somatostatin receptors?

95. ^{111}In-octreotide.

96. What types of tumor can ^{111}In-octreotide image?

96. Most neuroendocrine tumors, meningioma, astrocytoma, breast cancer, small-cell lung cancer, and lymphoma.

97. What is MEN I (multiple endocrine neoplasia type 1) syndrome?

97. Pituitary adenoma, pancreatic islet cell tumor, and parathyroid adenoma.

98. Which of these malignancies demonstrate uptake on an ^{111}In-pentreotide scan?

a) Carcinoid.
b) Gastrinoma.
c) Small-cell lung cancer.
d) Pheochromocytoma or paragangliomas.
e) Pituitary adenoma.
f) All of the above.

98. f. All of the above.

99. True or false: The uptake on an ^{111}In-pentreotide scan is lower in insulinoma and medullary thyroid cancer, and this difference could be related to the different sensitivities of the receptor subtypes.

99. True.

100. How do you recognize an ^{111}In-pentreotide whole body scan?

100. Intense uptake in the spleen, liver, and kidneys (GI activity is also seen.)

101. What is the basic mechanism of uptake of ^{18}F-fluorodeoxyglucose (FDG) by malignant tumors?

101. Malignant tumors have a higher rate of glycolysis than normal tissue.

102. How do cells handle ^{18}F-FDG metabolically?

102. ^{18}F-FDG is transported into cells and phosphorylated to ^{18}F-FDG-6-phosphate, which cannot leave the cell and cannot undergo further metabolic degradation.

103. How is ^{18}F-FDG positron emission tomography (PET) imaging useful for the management of astrocytomas?

103. Uptake permits histologic grading, and the scan can be used to detect recurrence and differentiate radiation necrosis from tumor recurrence.

104. How is ^{18}F-FDG PET imaging useful for the management of head and neck tumors?

104. ^{18}F-FDG PET imaging is more accurate than CT or MRI for detecting the primary tumor and predicting its histologic grade.

105. What tracers are used for lymphoscintigraphy?

105. ^{99m}Tc–sulfur colloid (filtered), ^{99m}Tc–human serum albumin (HSA), ^{99m}Tc–antimony colloid, ^{99m}Tc dextran, and ^{99m}Tc-tilmanocept.

106. What is a sentinel node?

106. The first draining lymph node from a primary cancer.

107. How is lymphoscintigraphy useful in the management of malignant melanoma?

107. Lymphoscintigraphy can demonstrate the lymphatic drainage of the primary and the sentinel node and thereby determine which nodes should be resected surgically.

108. Where is the tracer injected for lymphoscintigraphic evaluation of malignant melanoma?

108. Intradermally at multiple sites around the skin lesion.

109. How is lymphoscintigraphy useful in the management of breast cancer?

109. Lymphoscintigraphy can identify the sentinel axillary or internal mammary lymph nodes, which can be either malignant or benign.

110. Where is the tracer injected for lymphoscintigraphic evaluation of breast cancer?

110. Injected intradermally within the peritumoral region with or without periareolar four-quadrant intradermal injections.

111. How is lymphoscintigraphy useful in the management of prostate carcinoma?

111. Lymphoscintigraphy can detect metastatic involvement of the internal, common iliac, and para-aortic lymph nodes.

112. Where is the tracer injected for lymphoscintigraphic evaluation of genitourinary tumors?

112. Into the ischiorectal fossa.

113. To which element does ^{67}Ga decay?

113. ^{67}Zn (stable).

114. Because gallium is excreted in milk, it is recommended to stop breastfeeding an infant for what period of time after injection?

114. 2 weeks.

115. Is the biologic half-life of ^{67}Ga-citrate less than, equal to, or more than the physical half-life?

115. More than the physical half-life.

116. The half-time of blood clearance of ^{67}Ga-citrate is __________.

116. less than 3 hours

117. What fraction of injected ^{67}Ga citrate is excreted from the body after 4 weeks? (Physical decay is not considered.)

117. One-third.

118. What fraction of ^{67}Ga-citrate is absorbed when it is administered orally?

119. Up to 1 week, is the percentage of injected ^{67}Ga-citrate excreted in urine less than or more than that excreted in stools?

120. The critical organ in ^{67}Ga-citrate imaging is __________.

121. ^{67}Ga negligibly binds to:

a) transferrin.
b) α-globulin.
c) albumin.
d) lactoferrin.
e) all of the above.

122. Gallium acts as a physiological analog of ferric ion and binds to all of the following types of cells, except:

a) lymphocytes.
b) neutrophils.
c) RBCs.
d) bacteria.
e) All of the above.

123. Gallium does not localize in most adenocarcinomas, except in __________.

124. The three clearly established uses of gallium tumor imaging are __________, __________, and __________.

125. Is gallium taken up by growing tumors or necrotic tumors?

126. Will irradiation of a tumor typically increase or decrease gallium uptake?

127. Will irradiation of head and neck tumors result in an increase or decrease of radiogallium uptake in the salivary glands?

128. True or false: Gallium uptake at an intramuscular injection site is usually pathological.

129. True or false: The normal small intestine does not secrete radiogallium.

130. Because the large intestine is one of the normal excretory pathways for radiogallium, the common methods of reducing diagnostic confusion in abdominal imaging are __________.

131. True or false: Gallium is actively bound to siderophores.

118. Less than 3%.

119. More than that excreted in stools.

120. the colon.

121. c, albumin.

122. c, RBCs.

123. lung and hepatoma.

124. metastatic melanoma; hepatoma versus pseudotumor of liver; monitoring of the response of lymphoma to chemotherapy

125. By growing tumors.

126. Decrease gallium uptake.

127. Increase of radiogallium uptake in the salivary glands.

128. False.

129. False.

130. gentle cathartics or enemas, high-fiber diet, imaging at various intervals.

131. True.

132. The source of lactoferrin is:

a) lymphocytes.
b) leukocytes.
c) bacteria.
d) fungus.
e) tissue macrophage.

132. b, leukocytes.

133. The source of siderophores is:

a) lymphocytes.
b) leukocytes.
c) bacteria.
d) fungus.
e) tissue macrophage.

133. c, bacteria.

134. Lactoferrin is physiologically produced by certain organs that localize gallium. These are (choose as many as apply):

a) lacrimal glands.
b) salivary glands.
c) lactating breast.
d) bone.
e) liver.

134. a, b, and c.

135. True or false: Deferoxamine, an iron-chelating agent, is a siderophore.

135. True.

136. Gallium is a physiologic analog of iron, and it shares an iron transport mechanism; however, the main difference between iron and gallium, intracellularly, is __________.

136. intracellularly bound iron is reduced and incorporated into the cytochrome oxidase transport system, whereas the gallium is trapped intracellularly but not reduced.

137. Is the gallium-binding affinity of lactoferrin less than or more than that of transferrin?

137. More than that of transferrin.

138. For the accuracy of detection of active osteomyelitis, is methylene diphosphonate (MDP) better than ^{67}Ga, or is ^{67}Ga better than MDP?

138. ^{67}Ga is better than MDP (methylene diphosphonate).

139. Gallium uptake is not usually seen in the following liver disorders (choose as many as apply):

a) adenoma.
b) hemangioma.
c) cirrhosis.
d) polycystic disease.
e) metastasis.

139. b, c, and d.

140. Lesion detectability by radiogallium is at the maximum when the lesion size is:

a) less than 1 cm.
b) 1 to 2 cm.
c) 2 to 5 cm.
d) 5 to 9 cm.
e) greater than 9 cm.

140. c, 2 to 5 cm.

141. True or false: The accuracy of a gallium scan in the evaluation of abdominal disorders is higher in children than in adults.

141. True.

142. The reported highest sensitivity (~100%) of gallium imaging is for__________.

142. Burkitt's lymphoma, pyogenic acute osteomyelitis (untreated), and pyogenic acute arthritis (untreated)

143. True or false: Discordance between ^{99m}Tc–sulfur colloid and gallium liver images is essential for the diagnosis of hepatoma.

143. True.

144. Does a positive or a negative gallium scan imply poor prognosis in multiple myeloma and neuroblastoma?

144. Positive.

145. Is the gallium scan positive or negative in acute rheumatoid arthritis?

145. Positive.

146. Differential diagnosis of negative chest X-ray and positive gallium scans includes __________.

146. pneumocystis carinii pneumonia (PCP), cytomegalovirus infection, pulmonary drug toxicity, sarcoidosis, and lymphocytic interstitial pneumonitis

147. Abnormal chest X-rays and normal gallium scans of lungs may be seen in __________.

147. Kaposi's sarcoma, pulmonary fibrosis, treated sarcoidosis, and inactive tuberculosis

148. Positive gallium scans and negative computed tomography/ultrasound (CT/US) of the abdomen may be seen in __________.

148. acute inflammation (e.g., peritonitis, pyelonephritis, and cystitis)

For questions 149 through 154, match the statements with the appropriate antibody structures by choosing from the following: antibody fragment, whole antibody, both, neither.

149. The major route of clearance is the liver.

149. Whole antibody.

150. The major route of clearance is the kidneys.

150. Antibody fragment.

151. Most often labeled with ^{111}In-chloride.

151. Whole antibody.

152. OncoScint.

152. Whole antibody.

153. It may be used to study sites of the spread of colorectal carcinoma.

153. Both.

154. Delayed views at several days are feasible.

154. Whole antibody.

155. The most frequent site for recurrence of colorectal carcinoma is:

a) the liver.
b) the lungs.
c) the extrahepatic abdomen and pelvis.
d) the brain.
e) all of the above equally.

155. c, the extrahepatic abdomen and pelvis.

156. What percentage of ovarian neoplasms expresses the TAG-72 antigen?

a) 50%.
b) 70%.
c) 80%.
d) 90%.
e) 98%.

156. d. 90%.

157. The monoclonal antibody (MAb) B72.3 seeks out which specific antigen in adenocarcinomas: CEA or TAG-72?

157. TAG-72.

158. The Food and Drug Administration (FDA) approved and recommended dose of ^{89}Sr for palliating painful bone metastases is:

a) 1 to 2 mCi (37–74 MBq).
b) 4 mCi (148 MBq).
c) 7 mCi (259 MBq).
d) 10 mCi (370 MBq).
e) 12 mCi (444 MBq).

158. b, 4 mCi (148 MBq).

159. Following treatment with ^{89}Sr, patients should be in isolation for:

a) 24 hours.
b) 48 hours.
c) 72 hours.
d) 5 days.
e) isolation is unnecessary.

159. e, isolation is unnecessary.

160. True or false: Positive localization on a ^{99m}Tc-phosphate bone scan is essential before a painful lesion can be effectively treated with ^{89}Sr.

160. True.

161. Of the following, the metastatic bone lesion least likely to responds to ^{89}Sr palliative therapy is:

a) multiple myeloma.
b) prostate carcinoma.
c) colon carcinoma.
d) breast carcinoma.

161. a, multiple myeloma.

162. The usual administered dose of ^{32}P for treating polycythemia vera is:

a) 1 to 1.5 mCi (37–55.5 MBq).
b) 2 to 5 mCi (74–185 MBq).
c) 5 to 10 mCi (185–370 MBq).
d) 10 to 15 mCi (370–555 MBq).
e) 20 to 25 mCi (740–925 MBq).

162. b, 2 to 5 mCi (74–185 MBq).

163. True or false: The effectiveness of ^{32}P therapy in treating polycythemia vera is generally attributed to the marrow-suppressive effects of its gamma (γ) emissions.

163. False.

164. Besides its use in treating polycythemia vera, some form of ^{32}P has been used to treat:

a) painful bone metastases.
b) leukemias.
c) malignant pleural effusions.
d) all the above.
e) none of the above.

164. d, all of the above.

165. In abscess detection, a false-negative gallium scan may be caused by (choose as many as apply):

a) the patient's receiving a transfusion.
b) polycythemia vera.
c) leukopenia.
d) none of the above.

165. a and c.

166. True or false: Effective gallium scans can be performed with a low-energy collimator if one utilizes only the 90- and 180-keV gamma (γ) photons.

166. False.

For questions 167 through 171, match the statement with the best choice from the following: ^{67}Ga-citrate, ^{111}In-WBCs, both, neither.

167. Preferable for the study of infectious disease.

167. Both.

168. Preferable for the detection of *Pneumocystis* pneumonia in patients with AIDS.

168. ^{67}Ga citrate.

169. Monochromatic gamma (γ) emissions.

169. Neither.

170. Preferable for study of IBD.

170. ^{111}In-WBCs.

171. Effectively detects the presence of subphrenic abscess.

171. Both.

172. Studies with both ^{18}F-FDG and ^{11}C methionine show that metabolites in malignant lesions are __________ than those in benign lesions.

172. higher

173. True or false: Increased ^{18}F-FDG uptake is found in malignant neoplasms in the lung in adenocarcinoma but not in squamous cell types.

173. False.

174. True or false: The lack of increased uptake of ^{18}F-FDG in a pulmonary nodule larger than 1 cm is a reliable predictor of benignity; however, follow-up with CT might be needed, based on the clinical situation and Fleischner Society recommendations.

174. True.

175. True or false: PET scanning of the chest cannot help in distinguishing between benign and malignant causes of adenopathy.

175. False.

176. True or false: The lack of morphologic change of a malignant lesion on CT reliably predicts a poor response to therapy.

176. False.

177. True or false: Benign breast lesions accumulate ^{18}F-FDG to a degree similar to the surrounding normal breast tissue.

177. True.

178. True or false: One of the Medicare reimbursements approved for PET studies is to distinguish posttherapy necrosis and fibrosis from recurrent brain tumor.

178. True.

179. Of the following AIDS complications, good gallium uptake is least likely to occur in:

a) mycobacterial infection.
b) Hodgkin's disease.
c) tuberculous adenopathy.
d) Kaposi's sarcoma.
e) all of the above equally.

179. d, Kaposi's sarcoma.

180. Amyloidosis is most likely to show:

a) positive gallium and positive phosphate uptake.
b) positive gallium and negative phosphate uptake.
c) negative gallium and positive phosphate uptake.
d) negative gallium and negative phosphate uptake.

180. c, negative gallium and positive phosphate uptake.

181. Normal gallium scan findings at 72 hours may include uptake in all of the following, except:

a) salivary glands.
b) lacrimal glands.
c) liver.
d) kidney.
e) all of the above.

181. d, kidney.

182. Which of the following is not true regarding the use of nuclear imaging in the evaluation of IBD?

a) Small bowel involvement and skip areas suggest Crohn's disease.
b) Continuous involvement, including the rectum, without small bowel disease suggests ulcerative colitis.
c) ^{99m}Tc-HMPAO is the preferred agent, and imaging is performed at 1 to 2 hours.
d) ^{111}In-WBC imaging for evaluation of IBD is also performed at 4 hours after radiotracer administration.
e) None of the above.

182. d. ^{111}In-WBC imaging for evaluation of IBD is also performed at 4 hours after radiotracer administration.

183. True or false: FDG PET appears promising for the evaluation of infection, but its exact role still needs to be defined.

184. An 85-year-old woman with fever of undetermined origin. Gallium scan was done (▶Fig. 11.1a, b).

Which of the following statements is (are) true?

a) The gallium scan is normal.
b) The intense activity in the colon is consistent with colitis.
c) It is normal to see mild gallium activity in the kidneys beyond 24 hours after injection.
d) Gallium uptake in the right kidney is consistent with pyelonephritis.

183. True.

184. c and d

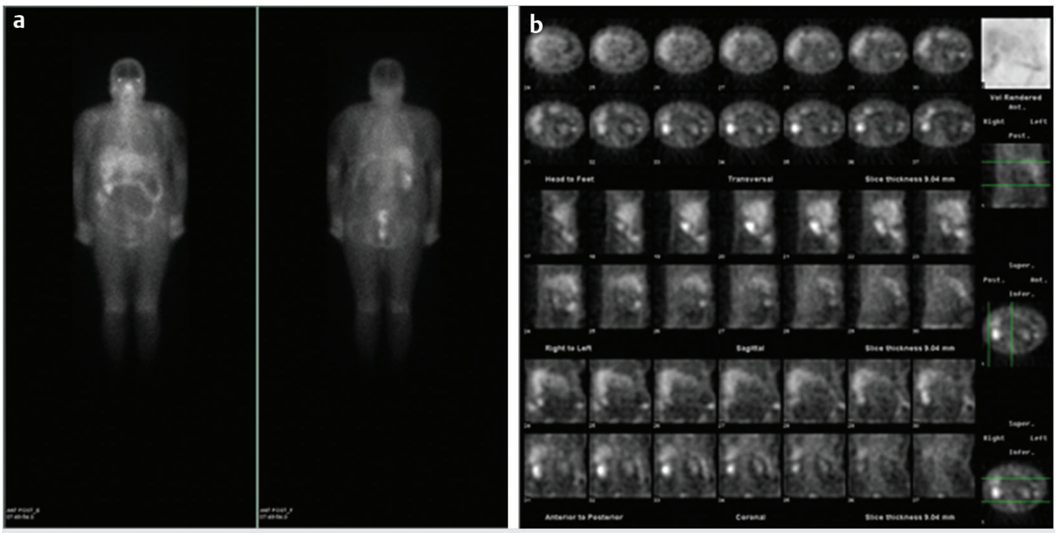

Fig. 11.1

185. Concerning gallium scan, which of the following statement(s) is (are) true?

a) Gallium is cyclotron produced.
b) Gallium physical half-life is 78 hours.
c) Gallium binds to transferrin, lactoferrin, siderophores, and ferritin.
d) Gallium decayed by electron capture.
e) All of the above.

185. e, All of the above.

186. Concerning ^{67}Ga, all of the following statements are true, except:

a) energies of the principal photons of ^{67}Ga are 93, 185, 300 and 395keV.
b) 15 to 25% of injected ^{67}Ga excreted by the kidney during the first 24 hours after injection.
c) biological half-life of ^{67}Ga beyond 24 hours after injection is 25 days.
d) usual dose of ^{67}Ga for infection is 10 mCi (370 MBq).

187. Concerning ^{67}Ga, which of the following statement(s) is (are) true?

a) Majority of ^{67}Ga excretion beyond 24 hours after injection is gastrointestinal (GI) tract.
b) Critical organ for ^{67}Ga is kidneys.
c) Critical organ for ^{67}Ga is colon.
d) Critical organ for ^{67}Ga is liver.

188. An 80-year-old man complains of back pain with history of abdominal aortic aneurysm. ^{111}In-WBC scan was performed (▶ Fig. 11.2a-c). Which of following statement(s) is (are) true?

a) There is increased ^{111}In-WBC uptake at L2–L3 level consistent with diskitis.
b) There is increased ^{111}In-WBC uptake anterior to L3 vertebra consistent with infection in the soft tissue.
c) ^{111}In-WBC is a radiopharmaceutical of choice in this clinical scenario.
d) ^{67}Ga is better than ^{111}In-WBC for evaluation of this kind of infection.

189. Indications for an ^{111}In-WBC study includes:

a) prosthetic infection.
b) intra-abdominal infection.
c) extremity osteomyelitis.
d) IBD.
e) all of the above.

190. Concerning ^{111}In-WBC scan, which of the following statement(s) is (are) true?

a) ^{111}In-WBC is a radiopharmaceutical of choice for evaluation of spinal infection.
b) Physical half-life of ^{111}In is 67 hours (2.8 days).
c) Leukocyte count less than 5,000/mm^3 might not result in an optimal scan.
d) Labeling efficiency of an ^{111}In-WBC is 75 to 90%.

186. d, usual dose of ^{67}Ga for infection is 5 mCi (185 MBq).

187. a and c.

188. b and c.

189. e, all of the above.

190. b, c, and d.

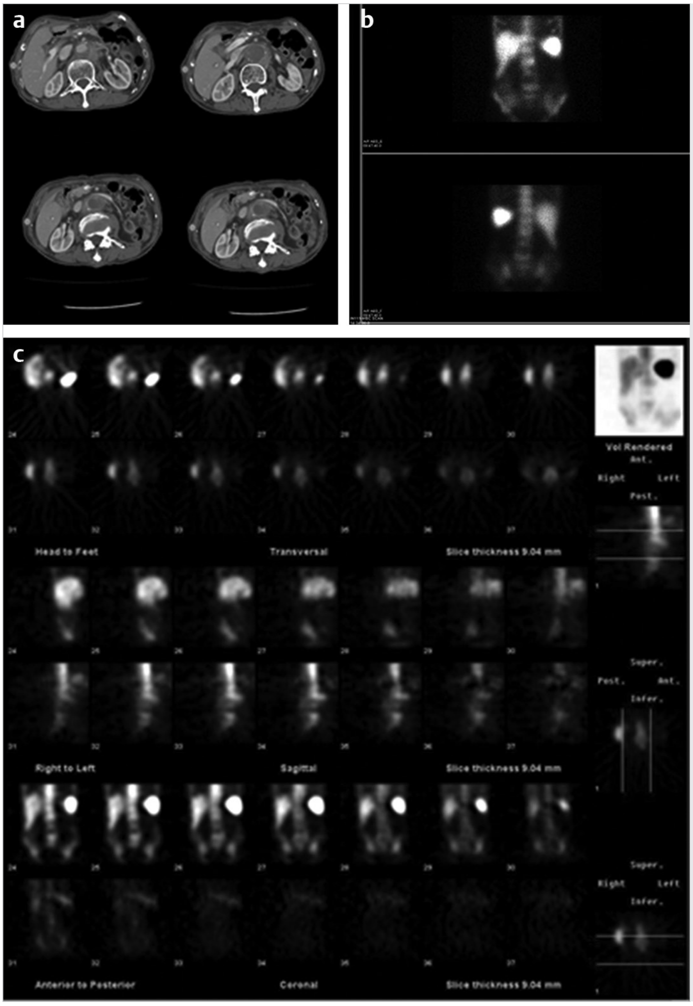

Fig. 11.2

191. Concerning ^{111}In-WBC scan, which of the following statement(s) is (are) true?

a) Target organ in ^{111}In-WBC scan is spleen.
b) ^{111}In-WBC uptake in lungs 4 hours after injection is physiologic.
c) ^{111}In-WBC uptake in lungs 24 hours after injection is physiologic.
d) ^{111}In photon energies are 173 and 247 keV.

191. a, b, and d.

192. A 75-year-old man with bacteremia. Planar and SPECT gallium scans are shown (▶Fig. 11.3a, b).

Which of the following statement(s) is (are) true?

a) No focal gallium uptake to suspect site of infection.
b) There is an elongated uptake at right paraspinal region extended medially into the spine.
c) There is abnormal increased uptake in the thyroid gland.
d) Uptake in the penile region is abnormal.

192. b and c.

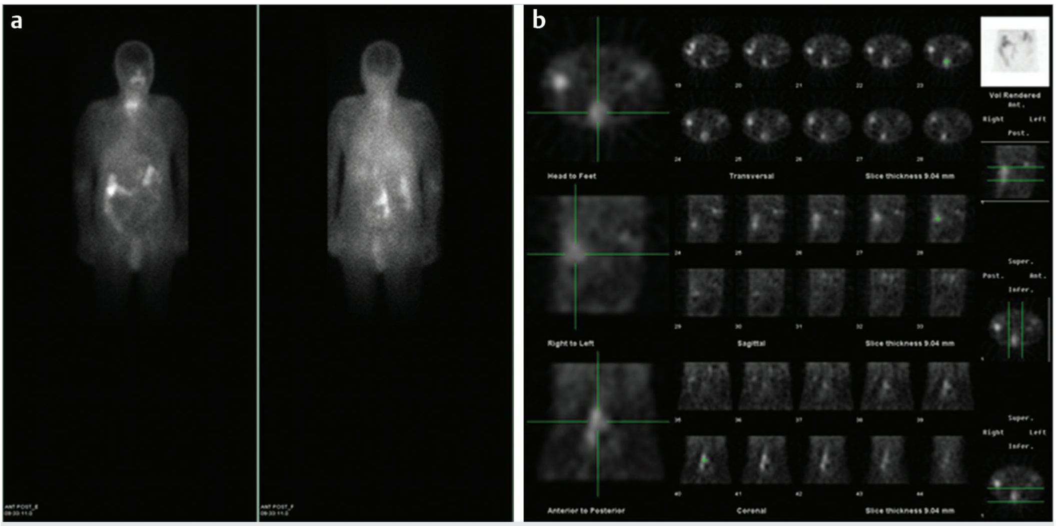

Fig. 11.3

193. Which of the following statement(s) is (are) true concerning ^{67}Ga scan?

a) It is a radiopharmaceutical of choice for evaluation of spinal infection.
b) Uninfected surgical wounds have increased ^{67}Ga uptake up to 2weeks.
c) Lactation causes intense physiologic uptake in female breasts.
d) Low-energy high-resolution collimator is used in ^{67}Ga imaging.

193. a, b, and c.

194. Choose the correct statement(s) below.

a) ^{67}Ga decays to ^{67}Zn (stable).
b) Breast feeding needs not be stopped after ^{67}Ga injection.
c) Breast feeding needs be stopped for 2 weeks after ^{67}Ga injection.
d) ^{67}Ga uptake at an intramuscular injection is usually physiologic.

194. a, c, and d.

195. ^{67}Ga binds to all of the following, except:

a) lymphocytes.
b) neutrophils.
c) RBCs.
d) bacteria.

195. c.

196. A 70-year-old woman, a year post right hip replacement, complains of pain in the right hip. Bone scan (upper row), ^{111}In-WBC scan (middle row), and bone marrow scan (lower row) are shown (▶Fig. 11.4).

Which of the following statement(s) is (are) true?

a) The findings are consistent with fracture.
b) The findings are consistent with prosthetic loosening.
c) The findings are consistent with prosthetic infection.
d) The findings are consistent with heterotopic bone formation.

196. c.

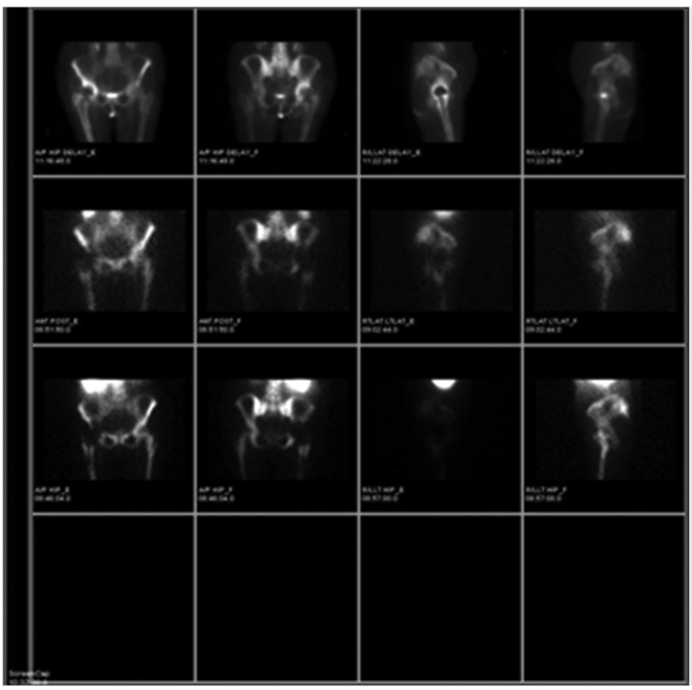

Fig. 11.4

197. True or false?

a) ^{67}Ga is a radiopharmaceutical of choice to evaluate complicated hip prosthesis.
b) ^{111}In-WBC is a radiopharmaceutical of choice to evaluate complicated hip prosthesis.
c) When both ^{111}In-WBC scan and ^{99m}Tc–sulfur colloid scan need to be performed, ^{99m}Tc–sulfur colloid scan is done first, followed by ^{111}In-WBC scan.
d) Simultaneous dual isotope acquisition using different energy window.

197. b, c, and d are true; a is false.

198. True or false?

a) Three-phase bone scan serves as a road map.
b) If ^{111}In-WBC scan is normal, ^{99m}Tc–sulfur colloid scan is not necessary.
c) If ^{111}In-WBC showed a hyperactivity, ^{99m}Tc–sulfur colloid scan is necessary for differential diagnosis.
d) If ^{111}In-WBC showed a hyperactivity, the prosthesis is infected.

198. a, b, and c are true; d is false.

199. True or false?

a) ^{111}In-WBC and ^{99m}Tc–sulfur colloid showed hyperactivity in the same area; there is prosthetic infection.
b) ^{111}In-WBC showed hyperactivity and in the same area there is no ^{99m}Tc–sulfur colloid uptake; there is prosthetic infection.
c) Bone scan has hyperactivity focus in the same area of hyperactivity on ^{111}In-WBC; the prosthesis is infected.
d) Bone scan is normal and ^{111}In-WBC is normal; the prosthesis is not infected.

199. b and d are true; a and c are false.

200. A 49-year-old man with Charcot's deformity and chronic ulcer of the left foot. Bone scan (upper row), ^{111}In-WBC scan (middle row), and bone marrow scan (lower row) are shown (▶ Fig. 11.5).

Which of the following statement(s) is (are) true?

a) They are indeterminate for infection.
b) They are consistent with Charcot's joints without infection of the left midfoot.
c) They are consistent with Charcot's joints with infection of the left midfoot.
d) They are consistent with bilateral midfoot infection.

200. c.

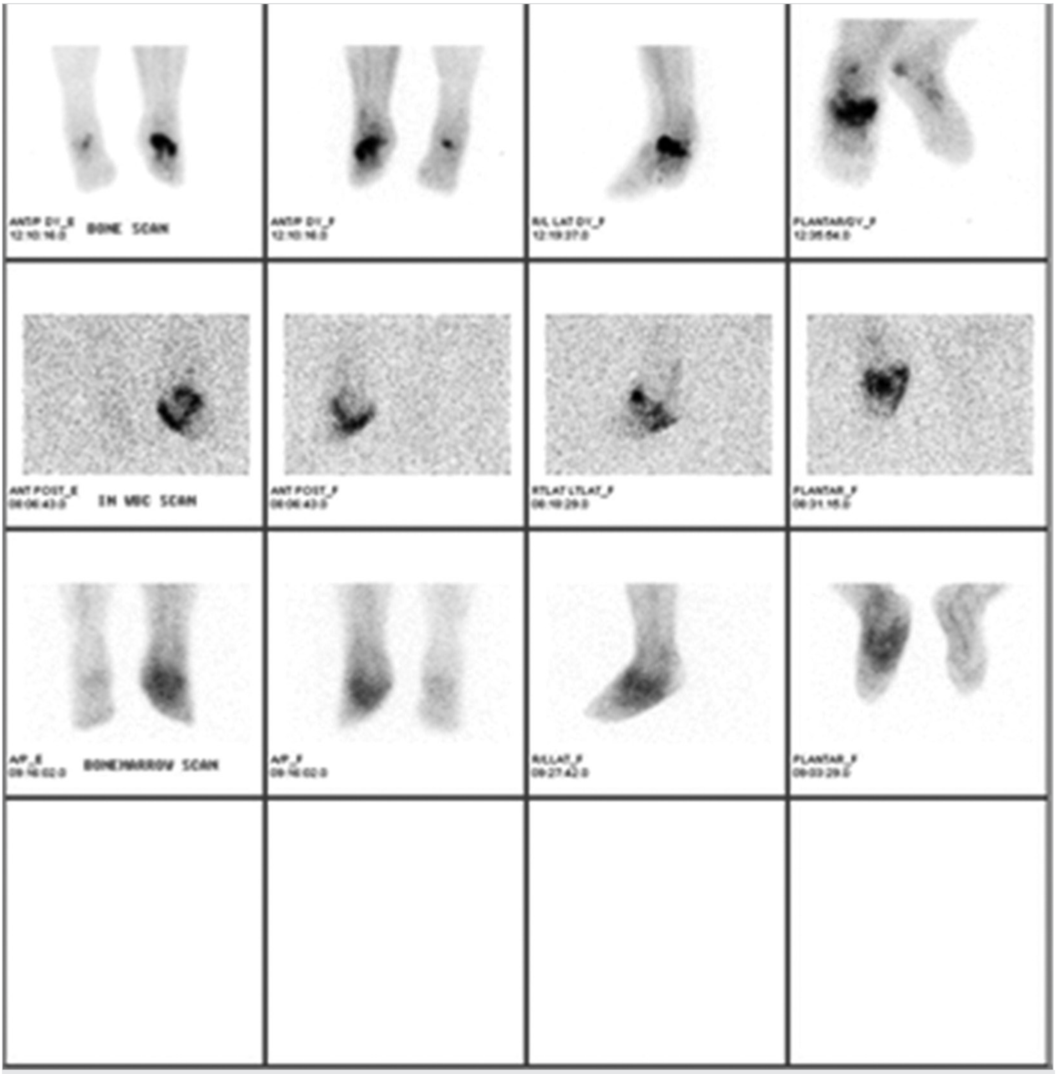

Fig. 11.5

201. True or false: In Charcot's joint:

a) Patients with diabetes mellitus, syringomyelia, syphilis, and other neuropathies are prone to this disease.
b) Associated with neurosensory deficit, loss of proprioception leads to repeated trauma.
c) Most commonly involves feet.
d) Infection in Charcot's joint is common.

201. a, b, and c are true; d is false.

202. Radiologic findings in Charcot's joint include:

a) joint destruction and fragmentation.
b) osseous sclerosis.
c) osteophyte formation.
d) osteolytic change.

202. a, b, and c are true; d is false

203. True or false: In Charcot's joint:

a) Bone scan shows hyperperfusion, hyperemia, and intense hyperactivity on skeletal phase.
b) ^{111}In-WBC shows increased uptake only if there is superimpose infection.
c) Bone marrow scan is invaluable in the diagnosis of superimpose infection.
d) Incongruent uptake between ^{111}In-WBC and ^{99m}Tc–sulfur colloid is seen in superimpose infection.

203. a, c, and d are true; b is false.

204. A child with human immunodeficiency virus positive (HIV[+]) and fever. A gallium scan is shown (▶Fig. 11.6).

Choose true statement(s) below.

a) Gallium uptake in the lungs of a young child is physiologic.
b) This is a common finding in MAI (mycobacterium avium intracellulare) infection.
c) The finding is consistent with PCP.
d) The finding is consistent with lymphocytic interstitial pneumonia (LIP).

204. c and d.

Fig. 11.6

205. In an HIV(+) patient, normal chest radiograph and positive gallium scan is seen in all, except:

a) PCP.
b) LIP.
c) cytomegalovirus infection.
d) Kaposi's sarcoma.

205. d, Kaposi's sarcoma.

206. Of the following AIDS complications, increased gallium uptake is least likely to occur in:

a) mycobacterial infection.
b) Hodgkin's disease.
c) tuberculous adenopathy.
d) Kaposi's sarcoma.

206. d, Kaposi's sarcoma.

207. Which of the following statement(s) is (are) true?

a) ^{201}Tl uptake in brain lesion in an HIV(+) patient indicates lymphoma or other malignancy.
b) No ^{201}Tl uptake in brain lesion in an HIV(+) patient indicates infectious pathology.
c) In an HIV(+) patient, a lung lesion that is ^{67}Ga negative and ^{201}Tl positive is consistent with Kaposi's sarcoma.
d) In an HIV(+) patient, a lung lesion that is ^{67}Ga negative and ^{201}Tl positive is consistent with lymphoma.

207. a, b, and c.

208. A 59-year-old man with history of neuroendocrine tumor of the pancreas. History of left hepatic lobectomy for metastasis (▶Fig. 11.7a–c).

Which statement(s) below is (are) true concerning the planar and SPECT ^{111}In-octreotide scan presented?

a) The history is misleading; the patient did not have left hepatic lobectomy.
b) Normal scan.
c) ^{111}In-octreotide uptake in kidneys; spleen is physiologic.
d) Two abnormal focal uptakes at the right lobe of the liver is consistent with metastatic neuroendocrine tumor.

208. c and d.

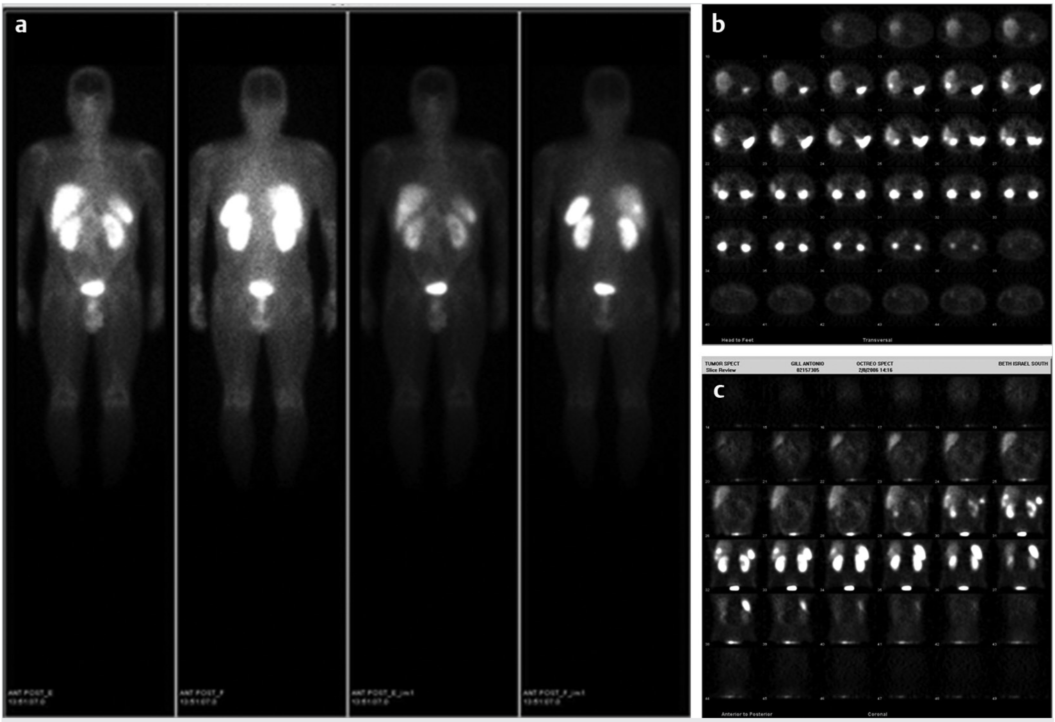

Fig. 11.7

209. Concerning ^{111}In-octreotide (^{111}In-pentetreotide), which of the following statement(s) is (are) true?

a) It is a somatostatin analog.
b) Intense uptake in liver, gallbladder, spleen, kidneys, and bladder is physiologic.
c) Faint uptake in pituitary and thyroid is normal.
d) Small amount is seen in the bowel in normal.
e) All of the above.

209. e, All of the above.

210. All of the following statements are true, except:

a) Somatostatin binds to all six somatostatin receptor subtypes 1, 2A, 2B, 3, 4, and 5.
b) Octreotide binds to somatostatin receptor subtypes 2 and 5 only.
c) Octreotide binds to all somatostatin receptor subtypes.
d) Octreotide binds to somatostatin receptors in tumor but not in nontumor sites.

210. c and d.

211. Which of the following statement(s) is (are) false?

a) Spleen is a critical organ for octreotide.
b) Because 80% of enteropancreatic neuroendocrine tumors express subtype 2 receptors, a majority of abdominal neuroendocrine tumors are octreotide positive.
c) Carcinoid secretes vasoactive substances and neuropeptides including serotonin.
d) Serotonin degrades to 5-hydroxyindoleacetic acid (HIAA), which is excreted in urine.
e) All of the above

211. e. All of the above.

212. A 42-year-old woman with possible pheochromocytoma. CT showed a 2-cm adrenal mass. Vanillylmandelic acid (VMA) = 1,400 mg/24 hr. Planar and SPECT images from tumor imaging are shown (▶Fig. 11.8a, b).

Concerning statements below, which statement(s) is (are) true?

a) The radiopharmaceutical used for this study was ^{111}In-octreotide.
b) The radiopharmaceutical used for this study was ^{123}I-MIBG (metaiodobenzylguanidine).
c) A right adrenal mass on prior imaging is an adrenal adenoma.
d) A right adrenal mass on prior imaging is a pheochromocytoma.

212. b and d.

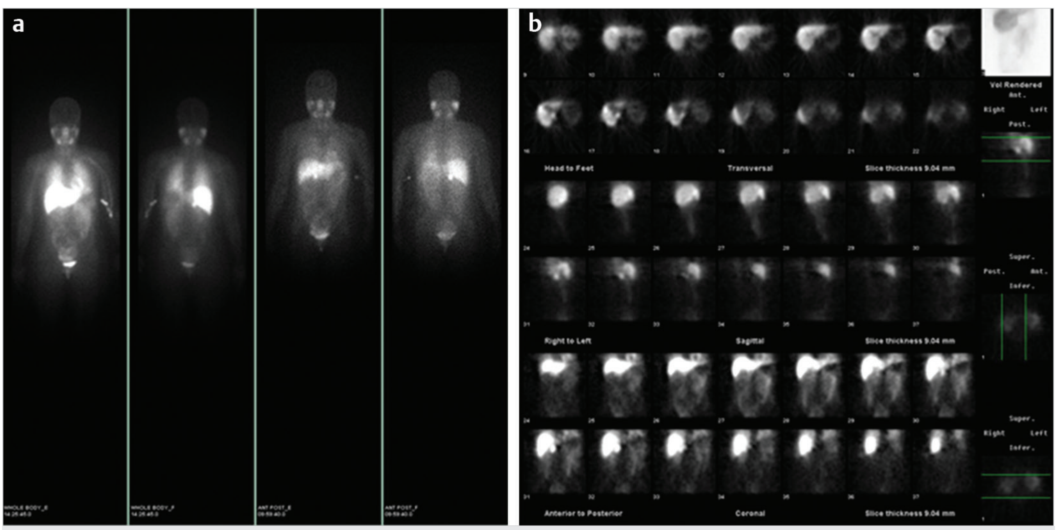

Fig. 11.8

213. Concerning pheochromocytoma, all of the following statements are true, except:

a) It is a relatively common tumor.
b) It arises from chromaffin cells (neural crest).
c) It secrets catecholamine whose metabolites include metanephrine and VMA.
d) It is bilateral in 10 to 15%.

214. All of the following statements are true, except:

a) ^{123}I-MIBG is used to detect adrenal medullary tumors.
b) ^{123}I-MIBG is a radiopharmaceutical of choice to detect primary pheochromocytoma.
c) ^{123}I-MIBG is used to detect adrenal cortical tumors.
d) MIBG structurally resembles norepinephrine and guanethidine.

215. Concerning MIBG, which of the following statement(s) is (are) true?

a) Localization in cells mainly through active transport, ATPase (adenosinetriphosphatase) dependent, through norepinephrine transporter (NET; uptake1 mechanism).
b) High uptake in normal sympathetically innervated tissue.
c) High uptake in tumors that express NET, specifically those of neural crest and neuroendocrine origin.
d) Normal adrenal medulla is not visualized on ^{123}I-MIBG scan because normal adrenal medulla does not concentrate MIBG.

216. A 47-year-old man with abnormal radiologic findings. Planar and SPECT images from In-Octreoscan are shown (▶Fig. 11.9a, b).

Choose statement(s) from below that is (are) true.

a) The scan finding is consistent with glomus vagale.
b) The scan finding is consistent with glomus tympanicum.
c) The scan finding is consistent with carotid body paraganglioma.
d) The scan finding is consistent with glomus jugulare.

213. a.

214. c.

215. a, b, and c.

216. c.

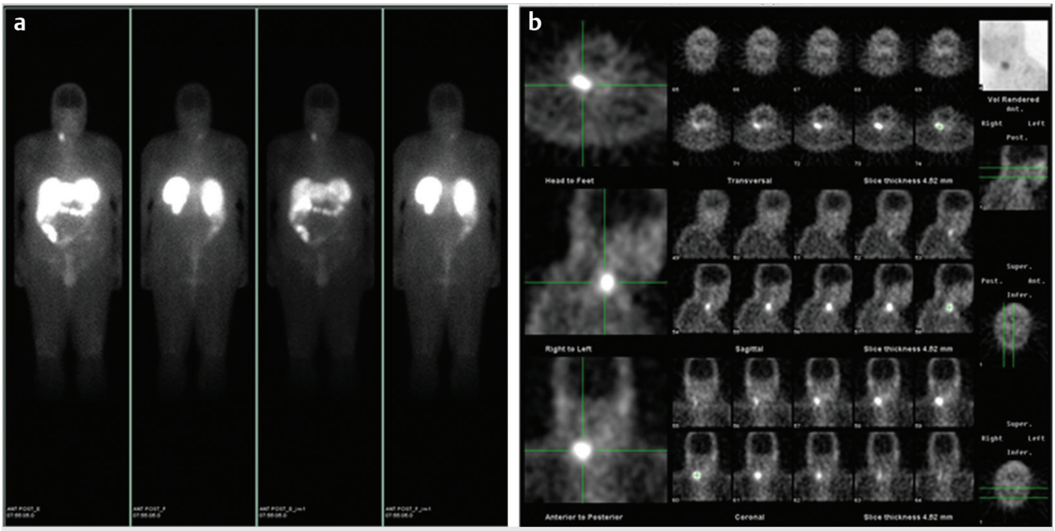

Fig. 11.9

217. Which of these malignancies demonstrate uptake on an ^{111}In-pentreotide scan?

a) Carcinoid.
b) Gastrinoma.
c) Small-cell lung cancer.
d) Pheochromocytoma or paragangliomas.
e) All of the above.

217. e. All of the above.

218. Which of the following statement(s) is (are) true?

a) Octreoscan is superior to ^{123}I-MIBG in detecting gastropancreatic neuroendocrine tumors.
b) ^{123}I-MIBG is superior to Octreoscan in detecting gastropancreatic neuroendocrine tumors.
c) Octreoscan is superior to ^{123}I-MIBG in detecting metastatic pheochromocytoma.
d) ^{123}I-MIBG is superior to In-octreoscan in detecting metastatic pheochromocytoma.

218. a and c.

219. All of the following statements are true, except:

a) An increased uptake of octreotide at sites of recent surgery is abnormal.
b) Octreotide is also a therapeutic agent in octreotide positive tumor.
c) Paragangliomas are common tumors of neural crest origin.
d) Paragangliomas most commonly arise from paraganglia.

219. c.

220. A 67-year-old woman with hearing difficulty in the left ear. Subsequently performed CT and magnetic resonance imaging (MRI) results were abnormal. Two tumor imagings were performed (▶Fig. 11.10a, b).

Which of the following statement(s) is (are) true?

a) The radiopharmaceutical used on the upper scan was ^{123}I-MIBG.
b) The radiopharmaceutical used on the lower scan was ^{111}In-octreotide.
c) The findings are consistent with glomus jugulare.
d) The findings are consistent with glomus vagale.
e) All of the above

220. e. All of the above.

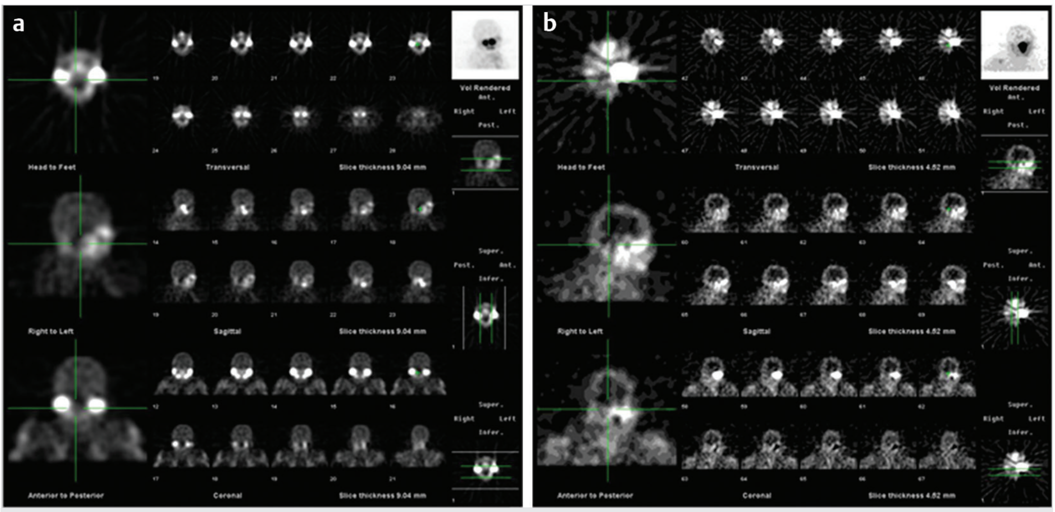

Fig. 11.10

221. Which of the following statement(s) is (are) true?

a) Pheochromocytomas are paragangliomas that arise in adrenal gland.
b) Most common extra-adrenal paragangliomas arise in the abdomen.
c) Paragangliomas that arise in head and neck are called glomus tumors.
d) Majority of paragangliomas of head and neck are malignant.

221. a and c.

222. Which of the following statement(s) is (are) true?

a) Majority of head and neck paragangliomas are nonsecreting and slow growing.
b) Somatostatin subtype 2 is the most prevalent receptor expressed.
c) Paragangliomas can be multicentric in 10 to 32% of cases.
d) Most of paragangliomas are sporadic but familial/hereditary in 9 to 25% of cases.
e) All of the above

223. All of the statements below are true, except:

a) ^{68}Ga-Dotatate is a new somatostatin analog SPECT/CT radiopharmaceutical.
b) Carotid paraganglioma is the most common head and neck paraganglioma that locates at the carotid bifurcation.
c) Glomus jugulare that locates at jugular fossa is the second most common head and neck paraganglioma.
d) Glomus tympanicum locates in the middle ear and glomus vagale along the course of vagus nerve.

222. e. All of the above.

223. a.

224. ^{111}In-WBC images (▶Fig. 11.11) demonstrate (check all that apply):

a) infection in left hemi pelvis.
b) sickle cell anemia.
c) altered vascular permeability of lungs.
d) cirrhosis.
e) colloid shift.

224. a and c.

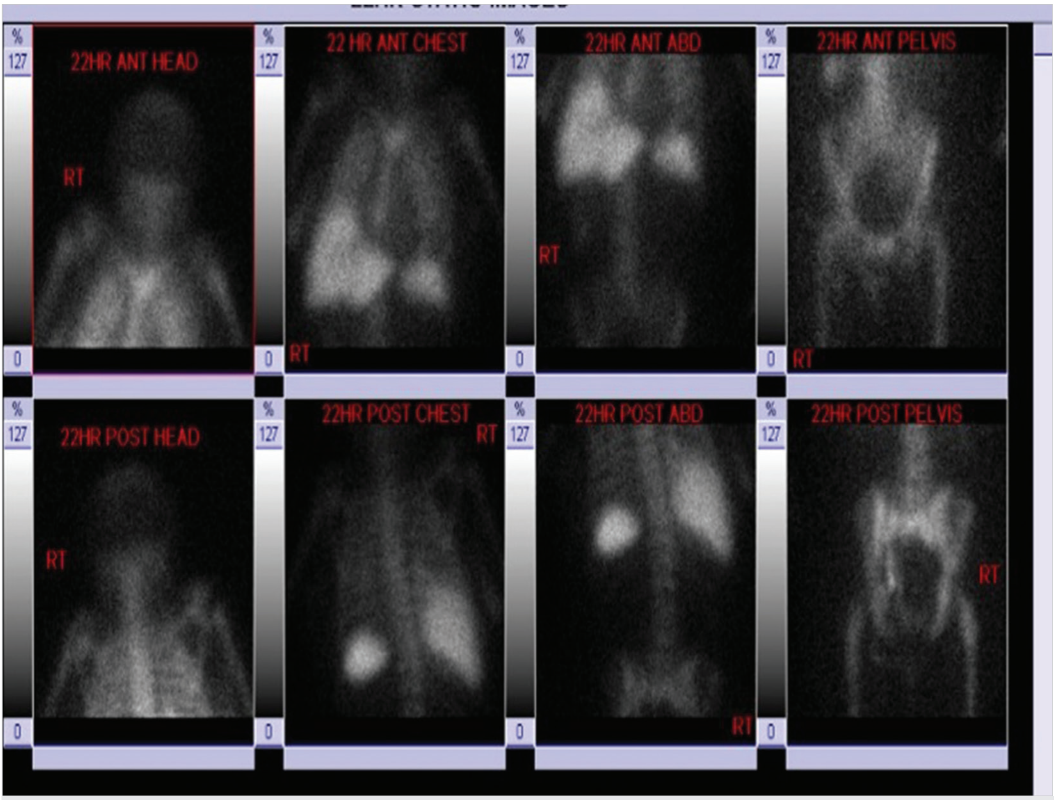

Fig. 11.11

12 Pulmonary

Questions

1. What is the main indication for ventilation perfusion scintigraphy?
2. What is the mortality rate from untreated pulmonary embolisms (PE)?
3. Name the two classes of radiopharmaceuticals used for ventilation scintigraphy.
4. Which three radioactive gases are available for ventilation scintigraphy?
5. Why can ^{127}Xe be used for postperfusion ventilation scanning?
6. What is the practical life of an ^{81}Rb–^{81m}Kr generator?
7. Why is ^{81m}Kr not more widely used for ventilation scanning?
8. Why can ^{81m}Kr be used for postperfusion imaging?
9. Why does xenon accumulate in the liver of some patients?
10. What radiopharmaceutical is most commonly used for radioaerosol imaging in the United States?
11. What is the appropriate aerosol particle size for radioaerosol ventilation scanning?
12. What happens to inhaled particles whose size is less than 0.1 µm (micrometers)?
13. What happens to inhaled particles whose size is greater than 2 to 3 µm?
14. How can both ventilation and perfusion imaging be performed with the same isotope?
15. What is the usual adult dosage for a ventilation scan with xenon?
16. What are the three phases of a xenon ventilation study?
17. What view is most commonly taken for a xenon ventilation study?

Answers

1. Evaluation of pulmonary embolism (PE).
2. 30%.
3. radioactive gases and radioaerosols.
4. ^{127}Xe, ^{133}Xe, and ^{81m}Kr.
5. The photon energies of ^{127}Xe are higher than those of ^{99m}Tc.
6. Approximately 12 hours.
7. Due to high costs and the impracticality of daily generator replacement.
8. The energy of the principal photon (191 keV) is higher than that of ^{99m}Tc.
9. Xenon is fat soluble and may accumulate in fatty livers.
10. ^{99m}Tc-DTPA.
11. 0.5 to 1.0 µm.
12. They are exhaled and thus not deposited in the lungs.
13. They settle in the large airways.
14. The dosage of the second study must be substantially greater than that of the first.
15. 10 to 20 mCi (370–740 MBq).
16. Washin (first breath), equilibrium, washout.
17. Posterior chest.

18. What does the patient breathe during the washin portion of a xenon ventilation study?

18. Radioactive xenon mixed with air.

19. What does the patient breathe during the equilibrium portion of a xenon ventilation study?

19. radioactive xenon mixed with air.

20. What does the patient breathe during the washout portion of a xenon ventilation study?

20. air (without radioactive xenon).

21. What fraction of the activity in a nebulizer is delivered to the lungs in a radioaerosol ventilation study?

21. 5 to 10%.

22. How much radioactivity is typically placed in the nebulizer for a radioaerosol ventilation study?

22. 25 to 27 mCi (925–999 MBq).

23. What is the biologic half-life of inhaled ^{99m}Tc diethylenetriamine pentaacetic acid (DTPA) in the lungs?

23. approximately 1 hour.

24. How does ^{99m}Tc-microaggregated albumin (MAA) localize in the lungs?

24. After intravenous injection, ^{99m}Tc-MAA is trapped in the pulmonary vascular bed on the first pass.

25. Why does ^{99m}Tc-MAA uptake in the lungs reflect lung blood flow?

25. Lung activity is proportional to regional pulmonary blood flow.

26. What is the biologic half-life of ^{99m}Tc-MAA in the lungs?

26. 2 to 3 hours.

27. What is the differential diagnosis of systemic organ uptake of ^{99m}Tc-MAA?

27. radiopharmaceutical impurities, right-to-left shunt.

28. What is the best organ to image to detect right-to-left shunting of ^{99m}Tc-MAA?

28. the brain.

29. What is the problem with administering too few particles of ^{99m}Tc-MAA?

29. The pattern of uptake is not based on a statistically valid distribution of particles to reflect blood flow.

30. What is the problem with administering too many particles of ^{99}mTc-MAA?

30. It may cause hemodynamic obstruction.

31. What is the minimum number of particles of ^{99m}Tc-MAA that should be injected for a perfusion scan?

31. 60,000.

32. What group of patients should always get the minimum number of particles of ^{99m}Tc-MAA?

32. patients with pulmonary hypertension, patients with a known right-to-left shunt, and children.

33. How does one adjust the number of particles of ^{99m}Tc-MAA that are administered to a patient?

33. Adjust the activity of ^{99m}Tc-pertechnetate and use higher specific-activity pertechnetate.

34. How will the number of particles of ^{99m}Tc-MAA that are administered to a patient change with decay of the kit?

34. The number of particles required to give a dosage increases with decay.

35. What is the usual dosage of ^{99m}Tc-MAA for a lung perfusion scan?

35. 2 to 5 mCi (74–185 MBq).

36. How long after injection of ^{99m}Tc-MAA can imaging for a lung perfusion scan begin?

36. immediately

37. What is the minimum number of counts that should be obtained for a lung perfusion scan?

37. 500,000.

38. What may occur if blood clots form in the syringe used to inject ^{99m}Tc-MAA for a lung perfusion scan?

38. Hot spots may appear in the lung.

39. What should be done with a syringe containing ^{99m}Tc-MAA immediately prior to injecting it into a patient?

39. The syringe should be agitated to prevent sedimentation of the particles. (If there is sedimentation of the particles, then they may remain in the syringe after injection.)

40. What is the normal pattern of uptake on the washin and equilibrium phases of a ^{133}Xe lung ventilation scan?

40. uniform distribution.

41. What can cause diffusely delayed washout of ^{133}Xe from the lungs during the washout phase of a lung ventilation scan in a normal patient?

41. difficulty breathing through the apparatus for delivering xenon.

42. What two organs outside the chest can show uptake of ^{133}Xe in a lung ventilation scan performed on a normal person?

42. the stomach (due to swallowed gas) and the liver. (If uptake in the liver is prominent, then a fatty liver should be suspected.)

43. What two organs outside the chest can show uptake of ^{99m}Tc-DTPA in a lung ventilation scan performed on a normal person?

43. the stomach (due to swallowed aerosol) and the kidneys.

44. What parts of the lung may be seen on an aerosol scan but never on a lung ventilation scan performed with gas?

44. the trachea and large airways.

45. What are two photopenic areas that will be seen in lung perfusion scans of normal patients?

45. the heart and the lung hila.

46. What is a ventilation perfusion mismatch?

46. The perfusion defect does not correspond to a ventilation scan abnormality.

47. What is the difference between a segmental and a nonsegmental perfusion defect on a perfusion scan?

47. A segmental defect reflects the vascular territory of a pulmonary artery branch; nonsegmental defects do not.

48. What is the name for the most commonly used criteria for diagnosing pulmonary emboli on a ventilation/perfusion (V/Q) scan?

48. PIOPED criteria.

49. What are the four diagnostic categories for PE with a V/Q scan?

49. normal, low probability, intermediate probability, and high probability.

50. What is the typical appearance of a low-probability V/Q scan?

50. matched ventilation perfusion abnormalities without corresponding radiographic findings.

51. In the Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED) trial, the probability of PE in a patient with a low-probability V/Q scan is in the range of __________.

51. 5 to 20%.

52. What is the probability of PE in a patient with normal lung perfusion?

52. less than 1%.

53. What is the probability of PE in a patient with a high-probability V/Q scan and a high clinical suspicion of PE?

53. 96%.

54. If a patient with a normal- or low-probability V/Q scan does not get anticoagulation therapy, what is the likelihood that the patient will have an adverse event due to an untreated PE?

54. less than 1%. (In the PIOPED study, no such complications were detected.)

55. What is the most common cause of a false-positive V/Q scan for acute PE?

55. unresolved chronic PE.

56. What factors predispose to rapid and complete resolution of pulmonary emboli?

56. young age, small emboli, and no comorbidities.

57. How quickly can pulmonary emboli resolve?

57. 1 day.

58. What is the maximum length of time that may be required for pulmonary emboli to resolve?

58. They can last for the life of the patient.

59. How can the pattern of a perfusion scan in a patient with a PE change without new emboli?

59. Proximal clots can break up and lodge more peripherally.

60. What is a stripe sign on a V/Q scan, and what is its meaning?

60. The stripe sign comes from preservation of blood flow at the pleural margin of a perfusion defect; pulmonary emboli usually cause perfusion abnormalities that extend to the pleural margin, and the stripe sign implies a low probability of PE.

61. How would a large amount of pleural fluid appear on a V/Q scan of a supine patient?

61. The pleural fluid uniformly attenuates the lung in the posterior images but not in the anterior images.

62. What is the fissure sign on a V/Q scan?

62. A linear perfusion defect along a pleural fissure due to pleural fluid in the fissure.

63. How can a perfusion scan be used to manage patients with lung cancer who are candidates for surgical resection?

63. Quantitation of the scan can be used to predict postoperative pulmonary function, based on the extent of surgery.

64. How can deep venous thrombosis be detected with radionuclide venography?

64. The patient's feet can be injected with ^{99m}Tc-MAA, and obstruction of the thigh veins can be detected.

65. The most commonly used radiotracer for perfusion imaging is __________, whose particle size must be greater than __________ but less than __________.

65. ^{99m}Tc-MAA; 8 µm; 100 µm.

66. An alternative perfusion agent is __________, which has the advantage of a more uniform particle size but the disadvantage of __________.

66. ^{99m}Tc-HAM (human albumin microspheres); a higher incidence of allergic reactions.

67. For perfusion studies, tracer is injected intravenously with the patient in the __________ position and imaged in __________ position.

67. supine; any

68. Why should the patient be supine when ^{99m}Tc-MAA is injected for a lung perfusion scan?

68. If the patient is upright, then there may be a basilar predominance of perfusion.

69. Why is position during injection important?

69. To distribute the pulmonary blood flow more evenly.

70. True or false: Normal pulmonary perfusion is relatively greater in the lung bases. Why?

70. true, because of gravity.

71. The range of microsphere size is __________, and that of MAA is __________.

71. 20 to 40 µm; 10 to 100 µm.

72. Approximately what fraction of the pulmonary capillary bed is occluded during a lung scan?

72. 1 part in 1,000.

73. What are the physical half-life and photon energy of ^{133}Xe?

73. 5 days and 81 keV.

74. What is the photon energy of ^{81m}Kr?

74. 190 keV.

75. Name four advantages of ^{133}Xe.

75. inexpensive, readily available, has good shelf life, and includes a washout phase that increases sensitivity for obstructive airway disease.

76. Name five disadvantages of ^{133}Xe.

76. poor image quality, high absorbed radiation dose, difficulty in obtaining multiple views, difficulty in performing the procedure in uncooperative patients, and a requirement for shielding.

77. Name five advantages of ^{81m}Kr.

77. high photon energy, multiple views, low patient radiation dose, ability to obtain ventilation after perfusion study, simultaneous acquisition perfusion and ventilation, and ease of performance, even in ventilator-assisted patients.

78. Name three disadvantages of ^{81m}Kr.

78. limited availability, expense, and lack of washout phase.

79. Name five advantages of radioaerosols (^{99m}Tc-DTPA).

79. inexpensive, readily available, can provide multiple views, make it possible to obtain ventilation after perfusion study, and allow administration of tracer to be performed in ventilator-assisted patients.

80. Name three disadvantages of aerosols.

80. lack of washout phase, may obtain poor images due to central deposition, and do not permit simultaneous (V/Q) image acquisition.

81. ^{81m}Kr, with a half-life of __________, is the product of __________, which has a physical half-life of __________.

81. 13 seconds; ^{81}Rb; 4.7 hours.

82. True or false: ^{81m}Kr is generator produced.

82. true.

83. True or false: ^{81}Rb is cyclotron produced.

83. true.

84. True or false: Albumin macroaggregates remain in the pulmonary capillary bed for weeks, limiting the number of follow-up perfusion scans that can be safely performed.

84. false.

85. The particles used for perfusion imaging are removed from the lung by__________.

85. phagocytosis.

86. True or false: The biologic half-life of MAA is longer than that of albumin microspheres.

86. false

87. When ^{133}Xe is used as the ventilation agent, ventilation precedes perfusion. Why?

87. Because Tc has a higher gamma (γ) energy, it can result in downscatter, degrading the ^{133}Xe image.

88. What is the advantage of acquiring ventilation and perfusion simultaneously?

88. It ensures corresponding positions for ventilation and perfusion.

89. Is a dual-headed camera necessary for simultaneous V/Q imaging?

89. no. (A dual peak with one head is adequate.)

90. True or false: In a patient with a high pretest probability of PE, the negative predictive value of a normal scan exceeds 95%.

90. true.

91. True or false: In a patient with a low pretest probability of PE, the positive predictive value of a positive scan exceeds 95%.

91. false.

92. Signs and symptoms of PE included in the classic triad are __________, __________, and __________.

92. dyspnea; pleuritic chest pain; hemoptysis.

93. True or false: If this triad is present, it has a positive predictive value for PE that exceeds 95%.

93. false.

94. True or false: V/Q scanning is nondiagnostic in most patients with pulmonary edema.

94. false.

95. True or false: Most patients with PE show infiltrate or effusion on properly exposed chest X-rays.

95. false.

96. According to the PIOPED interpretive criteria, a small perfusion defect composes less than what percentage of a lung segment?

96. 25%.

97. A large perfusion defect composes at least __________ of a lung segment.

97. 75%

98. Patients with normal chest X-rays with small perfusion defects (even with vent mismatch) on lung scans have a __________-probability scan for PE.

98. low

99. Patients with normal chest X-rays with matched defects on ventilation and perfusion scans have a __________-probability scan for PE.

99. low

100. Patients with a segmental perfusion defect substantially smaller than a corresponding radiographic abnormality (ventilation irrelevant) have a __________-probability scan for PE.

100. low

101. A segmental perfusion defect the same size as a chest X-ray and vent abnormality (a triple match) represents a/an __________-probability scan for PE.

101. intermediate (lower lobe); low (upper lobe)

102. A single moderate-sized perfusion defect (normal chest X-ray and vent) represents a/an __________-probability scan for PE.

102. intermediate

103. Other cases of V/Q mismatch include the following (other than acute PE).

103. old PE, nonthrombotic emboli, vasculitis, prior radiotherapy, bronchogenic carcinoma (CA), inactive tuberculosis (TB), arteriovenous (AV) malformation, lymphoma, fibrous mediastinitis, sarcoidosis, pulmonary hypertension, and vascular compression by enlarged hilar nodes.

104. True or false: The absence of perfusion to an entire lung is common with PE.

104. false.

105. The absence of perfusion to an entire lung should suggest __________.

105. central vascular compression by tumor.

106. A pneumonectomy patient may develop respiratory insufficiency if the postoperative forced expiratory volume in 1 second (FEV_1) is less than __________.

106. 0.8 L.

107. Split function studies determine the counts in each lung in anterior and posterior views by computing the __________.

107. arithmetic mean counts.

108. The postoperative FEV_1 is predicted by multiplying the __________by the fraction of the counts contributed by the lung that will not be removed.

108. preoperative FEV_1

109. In lung scanning, the stripe sign generally is reflective of:

a) pulmonary emboli.
b) nonembolic disease, such as chronic obstructive pulmonary disease (COPD).
c) pulmonary venous hypertension.
d) pleural fluid.
e) none of the above.

109. b, nonembolic disease, such as COPD.

110. Matched absence or near absence of perfusion and ventilation in an entire lung may be associated with:

a) lung carcinoma.
b) aspirated foreign body.
c) Swyer–James syndrome (SJS).
d) all of the above.
e) none of the above.

110. d, all of the above.

111. A reversal of pulmonary blood flow, with the upper lobes receiving more perfusion than the lower lobes, is most often associated with:

a) interstitial fibrosis.
b) pulmonary fluid.
c) pleural fluid.
d) pulmonary venous hypertension.
e) none of the above.

111. d, pulmonary venous hypertension.

112. The percentage of pulmonary emboli that proceed to infarction is approximately:

a) 0 to 5%.
b) 5 to 15%.
c) 15 to 30%.
d) 30 to 40%.
e) greater than 40%.

112. b, 5 to 15%.

For questions 113 through 118, match the finding with the appropriate scintigraphic interpretation by choosing among the following: low-probability lung scan, intermediate-probability lung scan, and high-probability lung scan.

113. Clear chest X-ray and multiple matched V/Q defects.

113. low-probability lung scan.

114. Single large segmental V/Q mismatch.

114. intermediate-probability lung scan.

115. Perfusion defect less than radiographic infiltrate.

115. low-probability lung scan.

116. Multiple small perfusion defects.

116. low-probability lung scan.

117. Lobar V/Q mismatch.

117. high-probability lung scan.

118. Perfusion defect equal to radiographic infiltrate.

118. intermediate-probability lung scan.

For questions 119 through 123, match the statement with the appropriate ventilation lung agent by choosing among the following: ^{81m}Kr, ^{99m}Tc-DTPA particles, and ^{133}Xe.

119. Associated with the lowest radiation dose.

119. ^{81m}Kr.

120. 5-day physical half-life.

120. ^{133}Xe.

121. Study generally is performed with the patient in only one position.

121. ^{133}Xe.

122. May be effectively performed following the perfusion study.

123. Often causes central “hot spots” in emphysematous patients.

124. The visualization of the kidneys on a ^{99m}Tc-MAA perfusion lung scan can be caused by:

a) right-to-left shunting.
b) free ^{99m}Tc.
c) MAA particles less than 10 µm in size.
d) all of the above.
e) none of the above.

125. True or false: Technegas is an ultrafine dispersion of ^{99m}Tc-labeled carbon in a carrier gas of argon and provides better ventilation images with the capability for single-photon emission computed tomography/computed tomography (SPECT-CT) and digital subtraction techniques.

126. True or false: Technegas is commercially available in Europe and Australia, but not in the United States.

127. What is D-dimer?

128. What are Well’s criteria?

129. What is the significance of a low Well’s score and negative D-dimer for evaluation of PE?

130. How does the pretest clinical probability affect the probability of PE on V/Q scan and computed tomography pulmonary angiography (CTPA) evaluation?

122. ^{81m}Kr.

123. ^{99m}Tc-DTPA particles.

124. d, all of the above.

125. true.

126. true.

127. D-dimer is a fibrin degradation product. A positive D-dimer can be nonspecific, whereas a negative D-dimer can exclude PE or DVT (deep vein thrombosis).

128. Clinical assessment of the signs and symptoms is performed to provide a probabilistic assessment for PE (> 6 is high, 2–6 is moderate, and < 2 is low). Modified Well’s criteria, as well as other classification models, are also available.

129. This combination excludes PE with a high negative predictive value (99.1–100%).

130. High clinical probability increases the positive predictive value and low clinical probability increases the negative predictive value of both CTPA and V/Q scans (based on Bayes’ theorem).

131. Which of the following findings are consistent with very-low-probability scan for PE?

a) Nonsegmental perfusion abnormality.
b) perfusion defect smaller than radiographic defect.
c) one to three small segmental perfusion defects.
d) upper lobe segmental triple match defect.
e) stripe sign.
f) all of the above.

132. What is the likelihood of a PE in a very-low-probability group?

133. Quantitative information from lung perfusion and ventilation scan is useful in which of the following conditions?

a) preoperative risk assessment prior to lung resection.
b) congenital heart diseases.
c) lung transplantation.
d) all of the above.
e) none of the above.

134. True or false: SPECT lung scans are more commonly performed in the United States than in Europe?

135. According to EANM (European Association for Nuclear Medicine), a segmental mismatched segment on a SPECT V/Q study should be interpreted as __________.

136. This imaging study (▶Fig. 12.1) is useful for which of the following?

a) Preoperative before lung surgery.
b) Assessment of relative lung perfusion.
c) Both A and B.
d) None of the above.

137. What is the finding on this VQ scan (▶Fig. 12.2)?

a) Normal scan.
b) Low probability (PE negative).
c) High probability (PE positive).
d) COPD.

138. What is the finding on this VQ scan (▶Fig. 12.3)?

a) Normal scan.
b) High probability.
c) Indeterminate.
d) COPD.

131. f, all of the above.

132. less than10%.

133. d, all of the above.

134. false.

135. PE present.

136. c, This is a lung perfusion quantification study, to assess relative perfusion in lung as well as different lobes/lung fields (sometimes the lung is divided into equal thirds instead rather than in segments shown here). The geometric mean of anterior and posterior counts is determined.

137. c, Multiple mismatched wedge-shaped segmental defects are seen.

138. a, Homogeneous ventilation and perfusion.

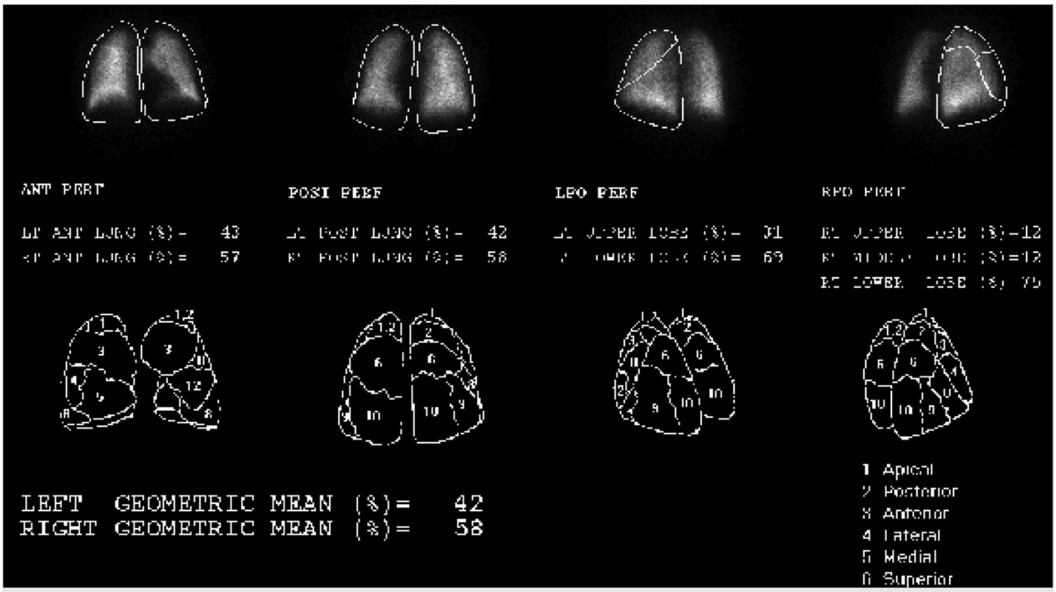

Fig. 12.1

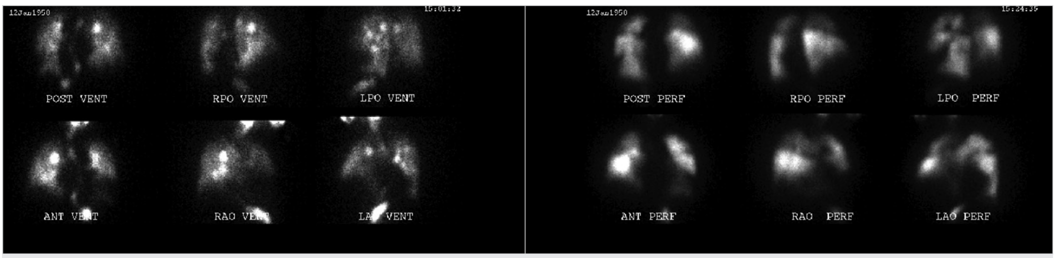

Fig. 12.2

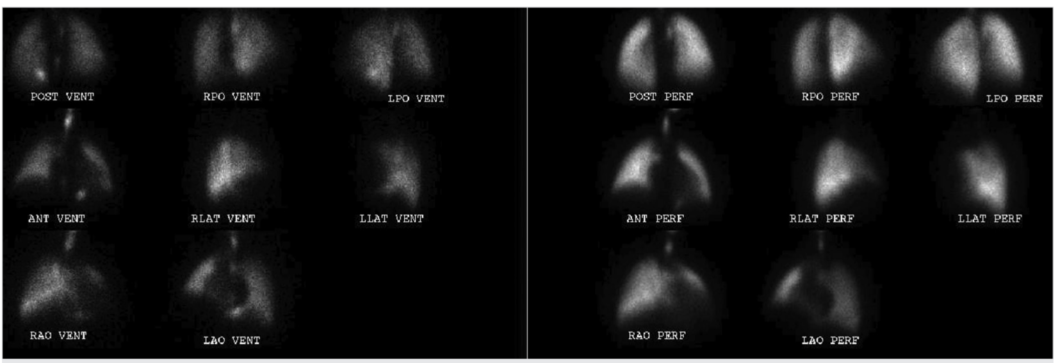

Fig. 12.3

139. What is the cause of the photopenic defect in the left lung (▶Fig. 12.4)?

a) COPD.
b) Pulmonary embolus.
c) Pacemaker artifact.
d) Clumping of tracer.

139. c, Pacemaker artifact.

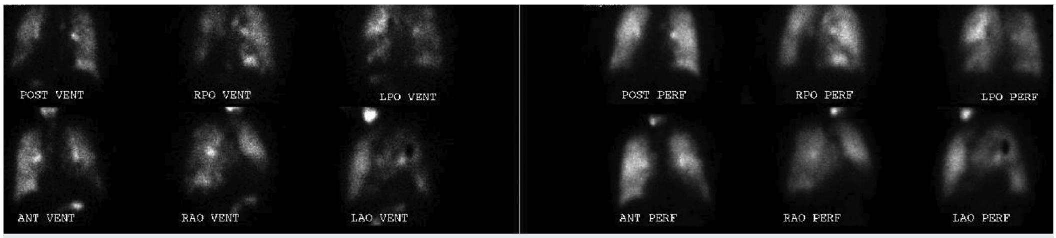

Fig. 12.4

140. Which one of the following is/are true regarding Tc-99m MAA injection on radioembolization planning angiogram (▶Fig. 12.5)?

a) No reduction in ^{90}Y dose for lung shunt fraction (LSF) < 10%.
b) 10 to 15% LSF, decrease ^{90}Y dose by 20%.
c) 15 to 20% LSF, decrease ^{90}Y dose by 40%.
d) LSF > 20%, ^{90}Y not recommended.
e) limit absorbed radiation to lung to less than 30 Gy.
f) all of the above.

140. f, all of the above.

141. Visualization of brain activity on ^{99m}Tc-MAA lung perfusion scintigraphy (▶Fig. 12.6) can be secondary to:

a) intracardiac right to left shunt.
b) left-to-right shunt.
c) pulmonary arteriovenous malformation (AVM)/arteriovenous fistula (AVF).
d) free pertechnetate or inadequate labeling.
e) hepatopulmonary syndrome.
f) all of the above.

141. a, c, and e.

142. Which of the following is least likely associated with a “stripe” sign on lung perfusion scan (▶Fig. 12.7)?

a) pulmonary hypertension.
b) smoking/emphysema.
c) shine through in cases where only limited planar projection images were obtained and SPECT imaging was not available.
d) reperfusion/resolving PE.

142. d, reperfusion/resolving PE.

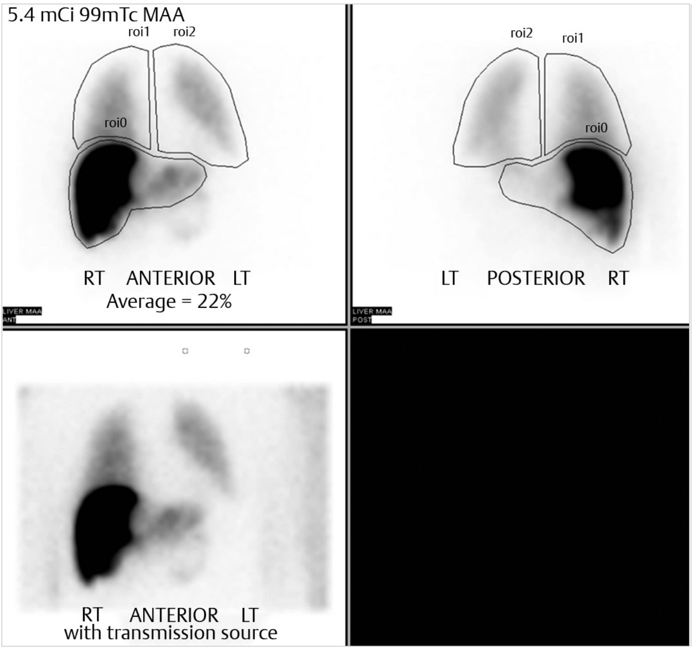

Fig. 12.5

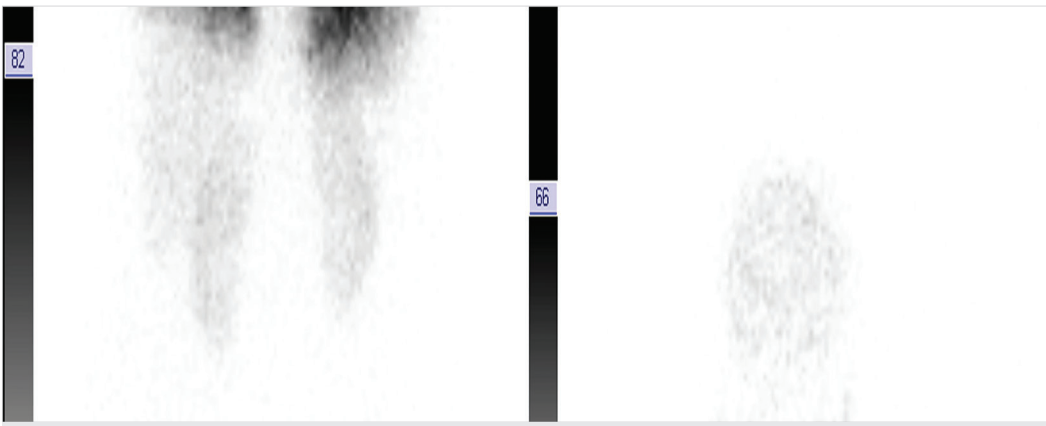

Fig. 12.6

143. Abnormal retention of ^{133}Xe on ventilation scan (▶Fig. 12.8) is consistent with ________________.

144. Differential lung perfusion studies (▶Fig. 12.9) are significant for:

a) pneumonectomy or lobectomy planning.
b) pretransplant workup.
c) post single lung transplant evaluation.
d) congenital heart disease, pre- and post-interventions.
e) all of the above.

143. obstructive lung disease.

144. e, all of the above.

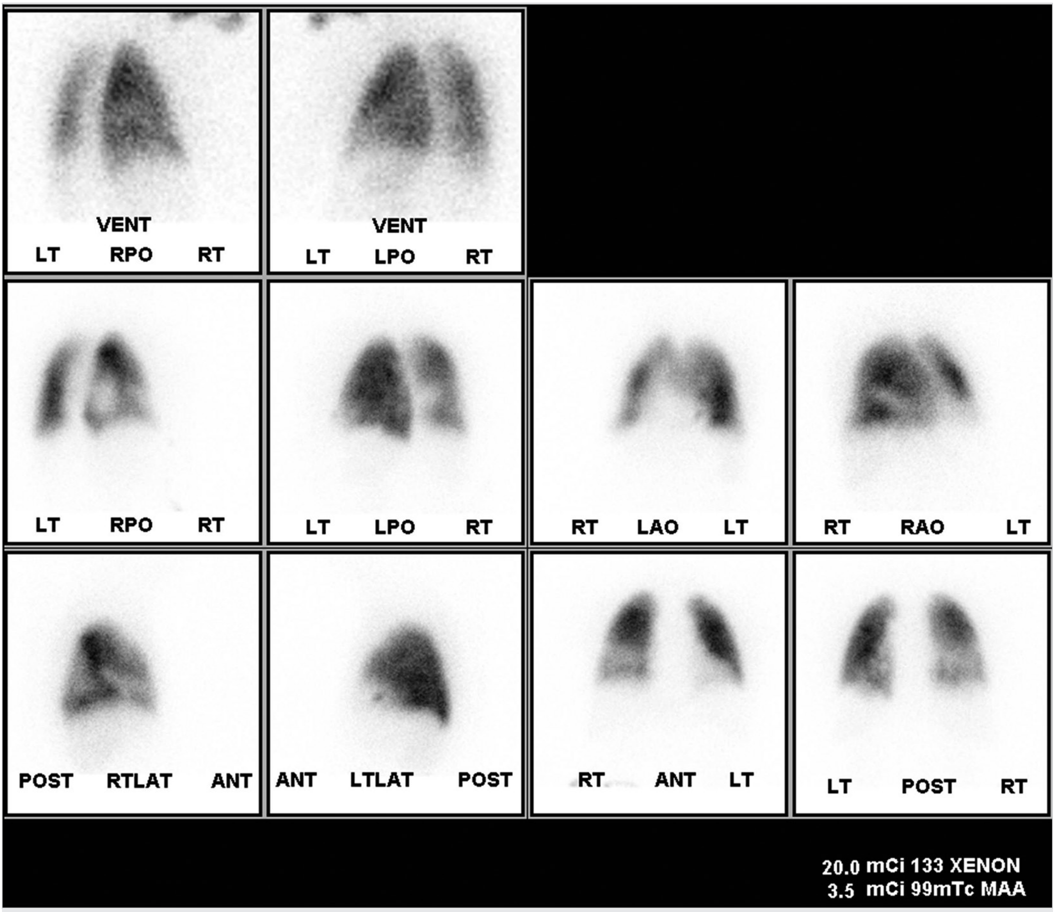

Fig. 12.7

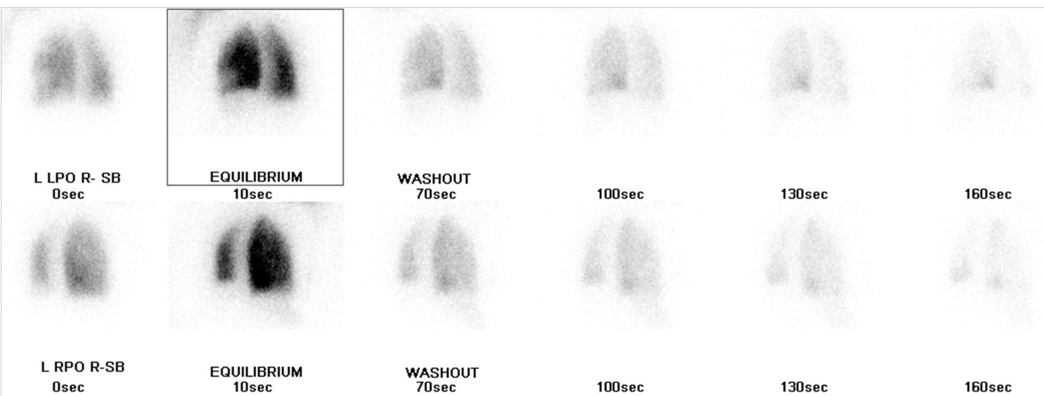

Fig. 12.8

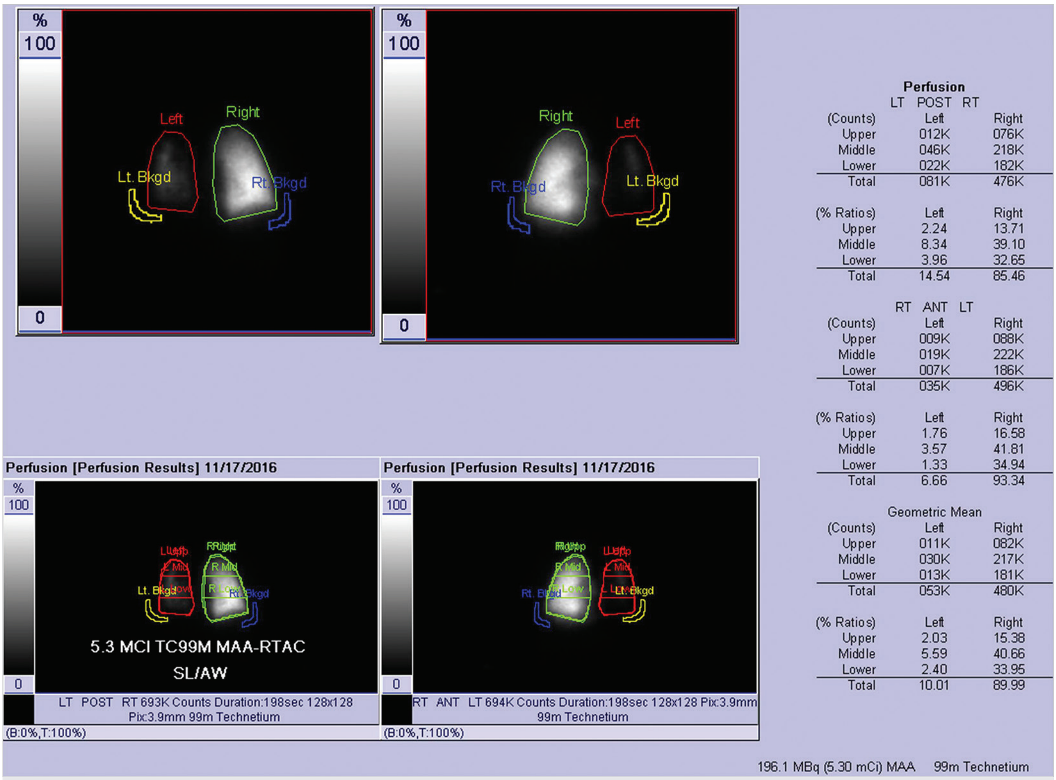

Fig. 12.9

145. Uptake and retention of ^{133}Xe in liver is seen in ____________________________ (▶Fig. 12.10).

145. fatty infiltration of the liver

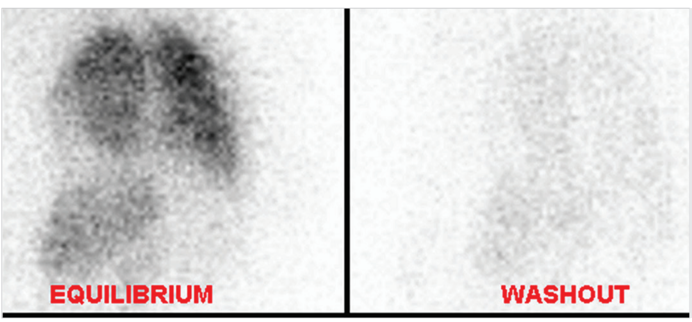

Fig. 12.10

146. Patient has normal chest X-ray and hypoxia. Based on the images below (▶Fig. 12.11), the findings are suggestive for:

a) high probability for PE.
b) reverse mismatch.
c) intermediate probability for PE.
d) very high probability for PE.

146. b, reverse mismatch.

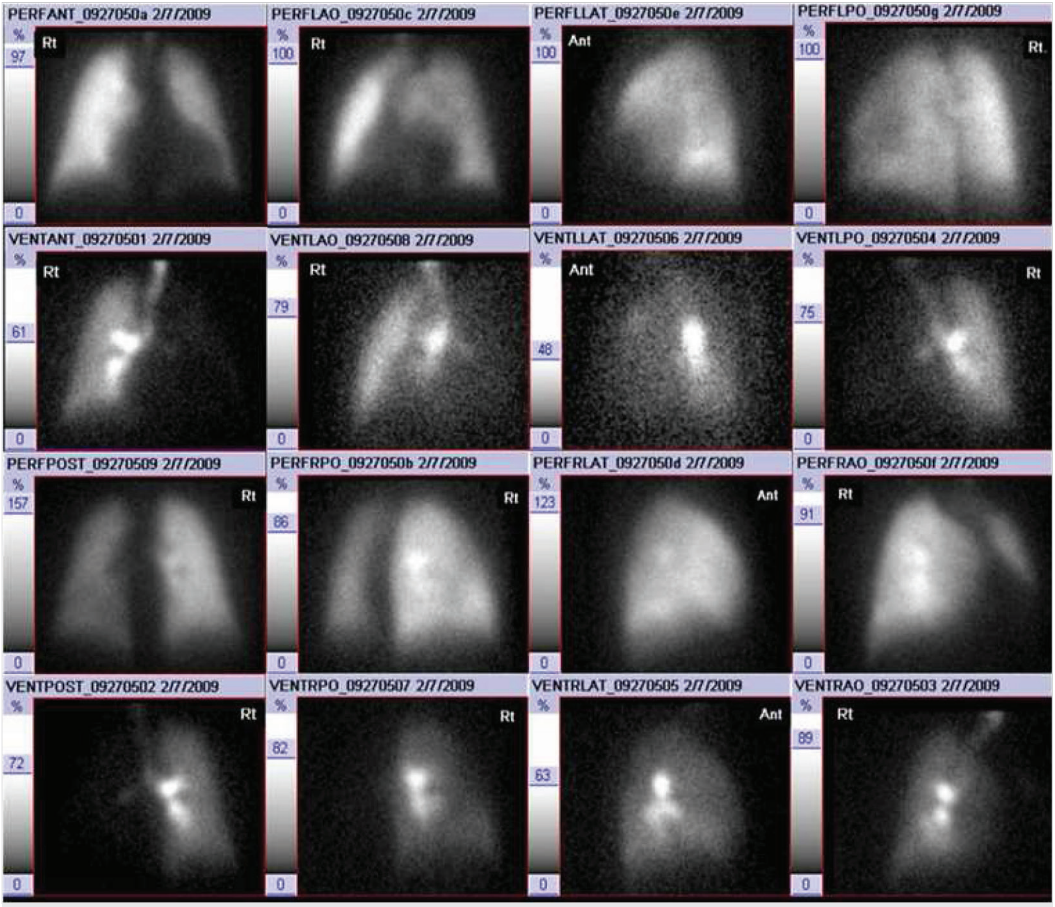

Fig. 12.11

Part III

Positron Emission Tomography/Computed Tomography

III

13 Basics of Positron Emission Tomography

Questions

1. True or false: ^{18}F emits a positron.
2. True or false: ^{15}O emits a positron.
3. True or false: ^{99m}Tc emits a positron.
4. True or false: ^{201}Tl emits a positron.
5. True or false: ^{11}C emits a positron.
6. Are positron-emitting radionuclides produced in a generator or in a cyclotron?
7. What are some of the positron emitters produced in a cyclotron?
8. What are some of the positron emitters produced in a generator?
9. Is a positron emitted from the nucleus of the atom or from the electron shells?
10. What happens to the positron emitted from a radionuclide?
11. Does the positron–electron annihilation take place in the radionuclide emitting the positron or at a short distance from the radionuclide?
12. After annihilation of a positron by an electron, which of the following occurs?
    a) Both the electron and positron lose energy and vanish.
    b) Two 511-keV photons traveling in nearly opposite directions are released.
    c) Two photons are released at 90 degrees to each other.
    d) none of the above.
13. Why are 511-keV photons not readily imaged by a standard gamma camera?
14. What method is used for localization of positron emissions in a positron emission tomography (PET) camera?

Answers

1. True.
2. True.
3. False.
4. False.
5. True.
6. In both.
7. ^{18}F, ^{13}N, ^{11}C, ^{15}O, ^{64}Cu, and ^{124}I.
8. ^{82}Ru, ^{68}Ga, and ^{62}Cu.
9. From the nucleus.
10. It collides with an electron and is annihilated.
11. At a short distance from the radionuclide.
12. b. Two 511-keV photons traveling in opposite directions are released.
13. The high-energy annihilation photons are not effectively absorbed by the usual crystal nor is collimation adequate.
14. Coincidence detection of the annihilation photons.

15. The scintillation crystals in modern PET scanners are commonly made of:

a) bismuth germinate (BSO [bismuth silicon oxide]).
b) lutetium oxyorthosilicate (LSO).
c) gadolinium silicate (GSO).
d) sodium iodide.
e) all of the above.

15. e, all of the above.

16. The spatial resolution of modern PET scanners is in the range of:

a) 2 mm.
b) 5 mm.
c) 10 mm.
d) 15 mm.
e) 25 mm (1 inch).

16. b, 5 mm.

17. The following positron-emitting radiopharmaceuticals are in use in clinical centers without a cyclotron (choose as many as apply):

a) ^{13}N-labeled ammonia for blood flow.
b) ^{15}O-labeled water for blood flow.
c) 2-[^{18}F]fluoro-2-deoxy-D-glucose ([18F]FDG) for metabolism.
d) ^{82}Rb for myocardial perfusion.
e) none of the above.

17. c and d.

18. The mechanism of FDG uptake in metabolically active cells is:

a) passive diffusion through the cell membrane.
b) facilitated transport via a glucose transporter (Glut) in the cell membrane.
c) active transport via adenosinetriphosphatase (ATPase) pump.
d) all of the above.
e) none of the above.

18. b, facilitated transport via a glucose transporter (Glut) in the cell membrane.

19. What happens to FDG once it is inside the cytoplasm?

a) It is taken up by mitochondria.
b) It is taken up by microsomes.
c) It undergoes phosphorylation to form FDG-6-phosphate (P).
d) All of the above.
e) None of the above.

19. c. It undergoes phosphorylation to form FDG-6-P.

20. Does FDG-6-P undergo further metabolism with the formation of pyruvate under aerobic conditions, or does it become trapped within the cell and undergo no further metabolism?

20. It becomes trapped within the cell and undergoes no further metabolism.

21. The rate of uptake of FDG by metabolically active cells is:

a) proportional to their metabolic activity.
b) increased in malignant cells, which have higher glucose utilization due to upregulation of hexokinase activity.
c) increased in malignant cells, which have increased glucose transport.
d) increased in activated inflammatory cells, which have increased glucose transport.
e) all of the above.

22. Is tissue uptake of FDG assessed visually, or is it assessed semiquantitatively by calculating the standard uptake value (SUV)?

23. To calculate SUV, which of the following parameter(s) must be known?

a) The amount of activity injected.
b) The patient's weight.
c) The concentration of activity in tissue.
d) The decay of activity between injection and measurement of concentration.
e) All of the above.

24. After correction for decay, the formula for calculation of tissue SUV is:

a) (tracer activity in tissue [μCi/g]) ÷ (injected dose[mCi] ÷ patient weight [kg]).
b) (tracer activity in tissue [mCi/g]) ÷ (injected dose [mCi] ÷ patient weight [kg] ÷ blood glucose level [mg/dL]).
c) none of the above.

25. Which of the following statements is true?

a) Mean SUV is the mathematical mean of all the pixels in the region of interest.
b) Minimum SUV is the value of the pixel with the lowest SUV.
c) Maximum SUV is the value of the pixel with the highest SUV.
d) All of the above.
e) None of the above.

21. e, all of the above.

22. Both.

23. e. All of the above.

24. a.

25. d. All of the above.

26. Normal tissue, such as lung, liver, and bone marrow, has mean SUVs ranging between:

a) 0.5 and 2.5.
b) 1.0 and 3.5.
c) 2.0 and 4.0.
d) 4.0 and 6.0.
e) 6.0 and 9.0.

27. Regarding currently available PET/computed tomography (PET/CT) scanners, which of the following two statements is true?

a) PET and CT are in the same gantry, and acquisition of PET and CT occurs simultaneously.
b) PET and CT gantries are in tandem; after the completion of a CT scan, the imaging table moves to the PET gantry for PET acquisition.

28. For quantification of PET data, the images must be attenuation corrected, which can be performed by:

a) measuring the attenuation map of the patient with an external radioactive source (e.g., ^{68}Ga).
b) using a look-up table to determine the appropriate attenuation values based on CT-derived Hounsfield units.
c) either of the above.

29. Oncology patients should fast for at least 4 hours before FDG injection to:

a) reduce the chance of aspiration, as patients often become nauseated following FDG injection.
b) reduce the possibility of hyperinsulinemia, which facilitates muscle uptake of the FDG, thereby reducing the availability of FDG for tumor uptake and potentially causing a false-negative study.
c) neither of the above.

30. What level of serum glucose is generally considered acceptable when performing an FDG-PET scan?

a) Less than 50 mg/dL.
b) Less than 100 mg/dL.
c) Less than 200 mg/dL.
d) Less than 300 mg/dL.
e) Less than 500 mg/dL.

26. a, 0.5 and 2.5.

27. b. PET and CT gantries are in tandem; after a CT scan is completed, the imaging table moves to the PET gantry for PET acquisition.

28. c, either of the above.

29. b, to reduce the possibility of hyperinsulinemia, which facilitates muscle uptake of the FDG.

30. c. Less than 200 mg/dL.

31. True or false: Contrary to the practice in oncology, when performing an FDG-viability study, patients should be glucose loaded to facilitate myocardial uptake of FDG.

31. True.

32. What is the half-life of ^{18}F?

32. 110 minutes.

33. The evaluation of the non–attenuation-corrected images is important in which of the following circumstances?

a) Increased focal activity near metal as in a possible infected hip prosthesis.
b) Evaluation of activity adjacent to a dense area of iodinated contrast.
c) Evaluation of misregistration artifacts.
d) All of the above.
e) None of the above.

33. d. All of the above.

34. How can one recognize a non–attenuation-corrected image?

34. High skin activity, high lung activity, decreased central activity, and increased peripheral activity.

35. The phenomenon whereby SUV of smaller or mobile lesions is reduced is termed __________.

35. partial volume averaging.

36. On dual time point ^{18}F-FDG imaging, uptake within malignant tissue generally ______ over time.

36. increases

37. What are some of the important factors to consider in a comparison of SUV values on two serial studies?

a) Body weight.
b) Glucose status.
c) Image reconstruction software utilized.
d) Injection to scan time.
e) Scanner model.
f) All of the above.

37. f. All of the above.

38. The SUV values in tumor and normal tissues of an obese patient are relatively __________.

38. higher.

39. What commonly used positron-emitting nuclides are produced through generators?

39. ^{82}Rb (the half-life of an ^{82}Sr generator is 25.3 days).

40. What is the half-life of ^{82}Rb?

40. 75 seconds.

41. For the available PET scintillator detectors (NaI, BGO, LSO, and GSO), match the following properties to them: highest light yield and highest energy resolution; hygroscopic; lowest light output and lowest energy resolution; shortest decay time with relatively good light output and energy resolution; short decay time but low light output.

41. Highest light yield and highest energy resolution, NaI; hygroscopic, NaI; lowest light output and lowest energy resolution, BGO; shortest decay time with relatively good light output and energy resolution, LSO; short decay time but low light output, GSO.

42. PET imaging using the radionuclides ^{11}C ($T_{1/2}$ = 20.3 minutes), ^{13}N ($T_{1/2}$ = 10 minutes), or ^{15}O ($T_{1/2}$ = 124 seconds) requires presence of an onsite __________.

43. What is time of flight (TOF) for PET systems?

44. What are the syringe shields for positron emitters made of?

45. Normal physiological uptake in certain individuals in the bilateral neck, supraclavicular, and paraspinal regions is related to __________.

46. Brown fat uptake can be minimized by:

a) sedatives/anxiolytics.
b) beta (β) blockers.
c) a warm environment.
d) all of the above.
e) none of the above.

47. Increased muscular uptake on a PET scan might be related to:

a) food consumed prior to the ^{18}F-FDG injection.
b) insulin administered prior to the ^{18}F-FDG administration.
c) intense muscular activity a day prior to the study.
d) muscular pathology.
e) all of the above.

48. Increased uptake following therapy may be seen in the __________ or _____________.

49. In the evaluation of cardiac sarcoidosis using ^{18}F-FDG PET, methods used to decrease constitutive cardiac uptake include:

a) prolonged fasting prior to scanning.
b) use of low carbohydrate diet on the day prior to scanning.
c) administration of heparin as a means of decreasing non-specific FDG uptake.
d) all of the above.
e) none of the above.

42. onsite cyclotron.

43. The ability to localize the annihilation event (250-600 keV) to a small region on the line-of-response is based on timing of when the annihilation photons strike the paired detectors (6-12 ns), thereby improving the resolution of the imaging system.

44. Tungsten.

45. brown fat.

46. d, all of the above.

47. e, all of the above.

48. thymus, bone marrow

49. d, all of the above.

50. Malignancies with low FDG uptake include:

50. bronchioalveolar lung cancer, renal malignancy, mucinous carcinoma of the ovary, colon cancer, breast cancer, cystic malignancies, lobular breast cancer, prostate cancer, pancreatic cancer, low-grade small-cell lymphoma, and malignant pleural effusions.

51. Activated inflammatory cells demonstrate increased expression of glucose transporters. Therefore, FDG PET is useful in the diagnosis of which of the following?

a) Fever of unknown origin.
b) Spinal osteomyelitis.
c) Potential use in failed joint prosthesis versus infection.
d) All of the above.
e) None of the above.

51. d, All of the above.

14 Basics of Computed Tomography Physics

Questions

1. What is the meaning of contrast resolution in computed tomography (CT)?
2. What is the meaning of spatial resolution?
3. What is the meaning of temporal resolution?
4. Define the terms “pixel” and “voxel.”
5. Define the components of any X-ray energy spectrum.
6. What are Hounsfield units?
7. What is the Hounsfield unit for water?
8. What is the Hounsfield unit for air?
9. What is the Hounsfield unit for fat?
10. What is a bone window?
11. What is a bone kernel?
12. An increase in milliamperes (mAs) results in all of the following except:
    a) increased noise
    b) no effect on image contrast
    c) radiation dose increased
    d) none of the above
13. Increased kVp (only) does not result in:
    a) decreased noise
    b) improved contrast resolution
    c) decreased radiation dose
    d) all of the above
    e) none of the above

Answers

1. The ability to differentiate small attenuation differences on the CT image.
2. The ability to discriminate between two adjacent objects; it is a function of pixel size.
3. The precision of a measurement with respect to time.
4. A pixel is a two-dimensional smallest sampled element in an image; a voxel is a three-dimensional smallest sampled element in an image.
5. The X-ray energy spectrum consists of bremsstrahlung or general continuous radiation and characteristic radiation.
6. The Hounsfield unit (HU) scale is a linear transformation of the original linear attenuation coefficient measurement.
7. Zero.
8. −1,000.
9. −30 to −120.
10. A large window width and a high window level.
11. A sharp, high-frequency or high-pass algorithm that enhances the edges of structures during mathematical reconstruction.
12. a, increased noise
13. c, decreased radiation dose

14. What is the 50/15 rule that describes the interrelationship between mAs and kVp?

14. A 50% decrease in the mAs is equivalent to a 15% increase in the kVp (or a doubling of the mAs is equivalent to a 15% reduction in the kVp), to maintain a comparable radiographic image.

15. Which of the following factors contributes to image noise?

a) Anatomical size
b) Thinner slices
c) Decreased pixel size
d) Increased scatter radiation
e) Decreased mAs
f) High spatial frequency filters
g) All of the above

15. g, all of the above

16. How can the radiation dose to the patient be decreased?

a) Decrease mAs
b) Increase pitch without compensation
c) Decrease kVp
d) All of the above
e) None of the above

16. d, all of the above

17. How are the parameters adjusted to decrease the radiation dose when the patients are children?

17. Appropriate reduction in kVp and mAs.

18. What parameters can be changed to produce diagnostic quality images in obese patients?

18. Increase mAs, increase kVp, increase noise index, use a smaller matrix, decrease the pitch factor, decrease gantry rotation speed, use thicker reconstructed slices, use a softer reconstruction filter/kernel.

15 Breast Cancer

Questions

1. Fluorodeoxyglucose positron emission tomography (FDG-PET) has limitations in detecting breast carcinoma in which of the following?
   a) Tumors smaller than 1 cm
   b) Well-differentiated tumors (tubular carcinoma and carcinoma in situ)
   c) Lobular carcinoma
   d) All of the above
   e) None of the above

For questions 2 through 5, match the statement with the appropriate choice by choosing among the following: better overall survival and relapse-free rate; PET not sensitive in detecting; more aggressive tumor; differentiation of malignant tumor from benign lesion with 90% accuracy.

2. Tumor less than 1 cm, well-differentiated subtype (tubular carcinoma, carcinoma in situ), and lobular carcinoma
3. Higher FDG uptake
4. FDG-PET with standard uptake value (SUV) over 2.5 to 3.0
5. Lower FDG uptake tumor
6. True or false: In axillary node staging, FDG-PET sensitivity is high enough to replace nodal sampling using ^{99m}Tc–sulfur colloid or blue dye sentinel node mapping.
7. The sensitivity of FDG-PET in detecting axillary lymph node metastasis depends primarily on the sizes and numbers of nodes involved. For early-stage breast carcinoma, the sensitivity for detecting axillary adenopathy is in the range of:
   a) 20 to 50%
   b) 40 to 60%
   c) 50 to 70%
   d) 60 to 80%
   e) 80 to 95%

Answers

1. d, all of the above
2. PET not sensitive in detecting
3. more aggressive tumor
4. differentiation of malignant tumor from benign lesion with 90% accuracy
5. better overall survival and relapse-free rate
6. False.
7. a, 20 to 50%

8. In cases of breast carcinoma metastasis to bone, which of the following statements are true? (Choose as many as apply.)

a) FDG-PET detects more metastasis than a bone scan.
b) Bone scans detect more metastasis than FDG-PET.
c) Bone scans detect more blastic metastasis than FDG-PET.
d) FDG-PET detects more lytic metastasis than a bone scan.
e) FDG-PET and bone scans are equally sensitive in detecting bone marrow metastasis.

9. The most common site of metastasis in breast carcinoma is:

a) brain
b) lung
c) liver
d) bone
e) skin

10. The current roles of FDG-PET in breast carcinoma include the following (choose as many as apply):

a) screening
b) detecting and defining recurrence
c) detecting metastasis
d) monitoring response to therapy
e) none of the above

11. Which of the following statements is true? (Choose as many as apply.)

a) FDG-PET can separate responders to neoadjuvant therapy from nonresponders earlier and more accurately than conventional imagings.
b) There is significant reduction in tumor SUV in responders.
c) There is no change or increase in SUV among nonresponders.
d) Low tumor perfusion is partially responsible for poor tumor response to intravenous chemotherapy.
e) None of the above.

8. c (bone scans detect more blastic metastasis than FDG-PET) and d (FDG-PET detects more lytic metastasis than a bone scan)

9. d, bone

10. b (detecting and defining recurrence), c (detecting metastasis), and d (monitoring response to therapy)

11. a, b, c, and d

12. Concerning FDG-PET imaging in radiation oncology, which of the following statements is (are) true? (Choose all which apply.)

a) Treatment planning changes due to FDG-PET findings in a significant number of patients.
b) After radiotherapy, FDG-PET should be delayed for at least 6 weeks.
c) A negative FDG-PET excludes a residual tumor.
d) FDG-PET detects more metastasis than anatomic imaging.
e) None of the above.

13. True or false: FES-PET (16α-[^{18}F]-fluoroestradiol-17β) images the estrogen receptor status of breast cancer.

14. Which of the following applications regarding the current coverage of breast cancer is not accurate?

a) ^{18}F-FDG is used for initial treatment strategy in evaluation of metastatic disease.
b) ^{18}F-FDG is used for subsequent treatment strategy.
c) ^{18}F-FDG is used for regional axillary nodal staging.
d) Sentinel nodal lymphoscintigraphy for regional nodal evaluation.
e) None of the above.

15. Which of the following descriptions regarding the staging of breast cancer is true?

a) T1 is less than 2 cm, T2 is 2 to 5 cm, T3 is greater than 5 cm, and T4 is a direct extension of chest/skin or ulceration.
b) N1, movable ipsilateral axillary nodes; N2, fixed/matted ipsilateral axillary nodes or ipsilateral internal mammary with normal axillary nodes; N3, ipsilateral axillary nodes with infraclavicular/internal mammary nodes or ipsilateral supraclavicular nodes.
c) N0, at least Stage I; N1, at least Stage II; N3, at least Stage IIIC; T4, at least Stage IIIC; M1, at least Stage IV.
d) All of the above.
e) None of the above.

12. a, b, and d

13. True.

14. c, ^{18}F-FDG is used for regional axillary nodal staging

15. d, all of the above

16. Which of the following statements regarding the treatment of breast cancer with respect to nodal staging is true?

a) N1 nodal disease: chemotherapy and/or hormonal therapy in addition to surgery
b) N2 nodal disease: additional radiation therapy
c) N3 nodal disease: pretreatment chemotherapy
d) All of the above
e) None of the above

17. Which of the following are established or experimental nuclear imaging modalities for breast cancer?

a) High-resolution positron emission mammography (PEM) with ^{18}F-FDG
b) Breast-specific gamma (γ) scintigraphy with ^{99m}Tc-sestamibi
c) ^{18}F-fluoroestradiol (FES) binding to estrogen receptors
d) Whole-body scan with ^{18}F-FDG
e) None of the above

18. True or false: Increased ^{18}F-FDG uptake in patients with estrogen receptor (ER)–positive breast cancers shortly after tamoxifen treatment indicates an aggressive and nonresponding tumor with poor prognosis.

19. A negative ^{18}F-FDG-PET postchemotherapy scan in breast cancer might still be associated with a recurrence rate of up to:

a) 5%
b) 25%
c) 50%
d) 75%
e) 90%

20. True or false: FDG-PET can substitute for bone scintigraphy, which remains the current standard imaging procedure for surveying the skeletal metastasis.

21. True or false: ^{18}F-FDG currently has no role in the axillary staging of newly diagnosed early-stage breast cancer.

16. d, all of the above

17. a, b, c, and d

18. False. (It is known as flare phenomenon.)

19. b, 25%

20. False. (It has a complementary role.)

21. True.

22. What is the significance of these internal mammary lymph nodes in a patient with bilateral breast cancer and silicone prosthesis (see ▶Fig. 15.1)?

a) Likely metastatic and should be biopsied
b) Likely reactive but can be followed with breast magnetic resonance imaging (MRI)
c) Non-FDG avid lymph nodes are always benign and do not require follow-up
d) May represent lymphoma and should be biopsied

22. b, likely reactive but can be followed with MRI—minimally avid internal mammary lymph nodes can be seen in the setting of reactive changes from silicone breast prosthesis

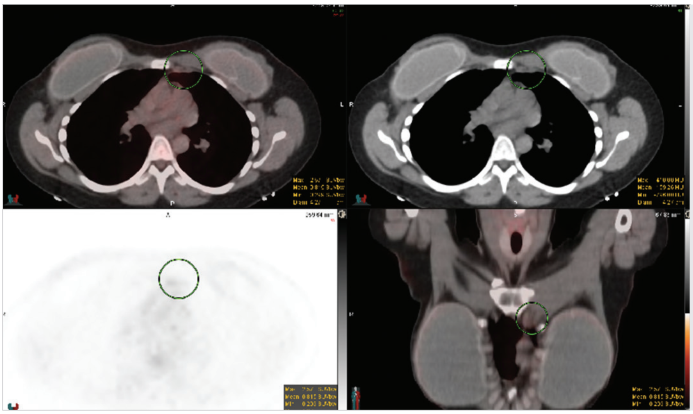

Fig. 15.1

23. Patient is status post breast surgery and axillary lymph node dissection (▶Fig. 15.2).

What is the most likely cause of the finding seen here?

a) Recurrent metastasis in a necrotic lymph node
b) Postsurgical seroma
c) Lymphoma
d) Lipoma

23. b, postsurgical seroma

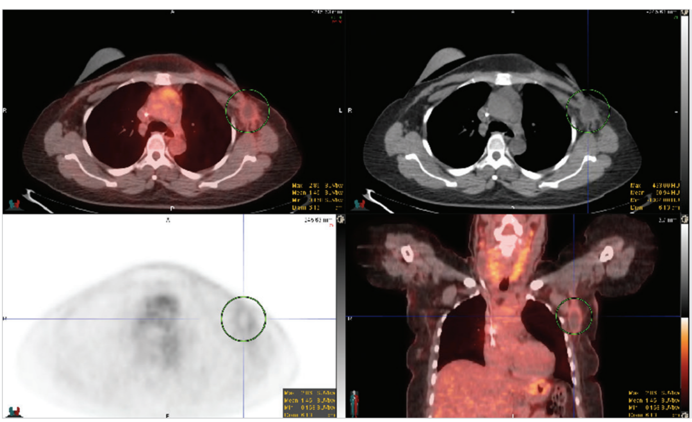

Fig. 15.2

24. What are the possible causes of this finding (▶Fig. 15.3)?

a) Breast cancer
b) Breast lymphoma
c) Fibroadenoma
d) All of the above

24. d, any of the above can—all of these may cause FDG uptake

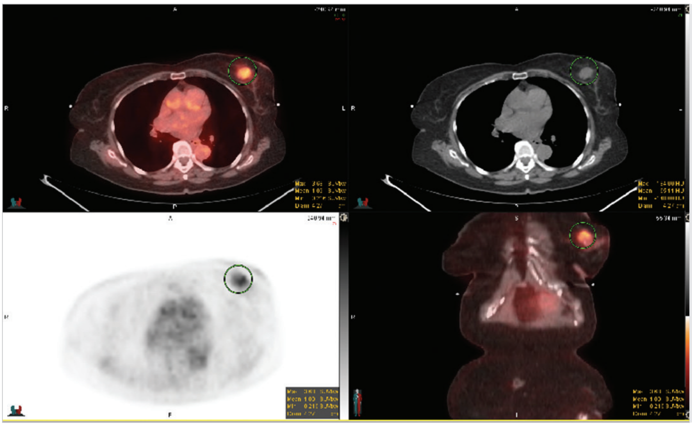

Fig. 15.3

25. What is the significance of this finding in a patient with history of right breast cancer and no other findings (▶Fig. 15.4)?

a) Likely metastatic
b) Likely reactive
c) Secondary to dose infiltration from left upper extremity injection
d) b or c

25. d

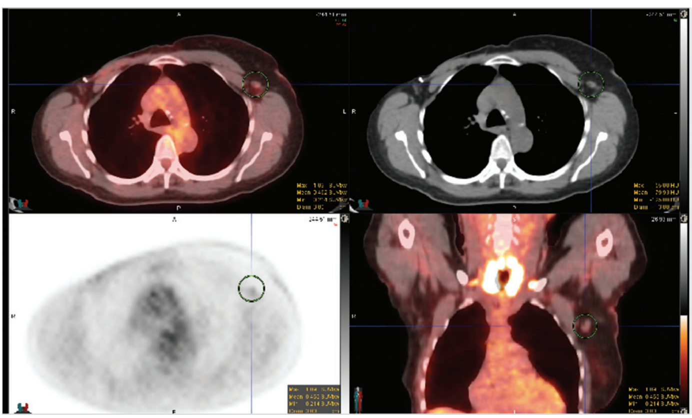

Fig. 15.4

26. Patient is status post right lumpectomy 1 week prior (▶Fig. 15.5).

What does this finding most likely represent?

a) Recurrence in the left chest wall
b) Postsurgical change
c) Brown fat uptake
d) Skeletal muscle uptake from elevated insulin level

26. b, postsurgical change

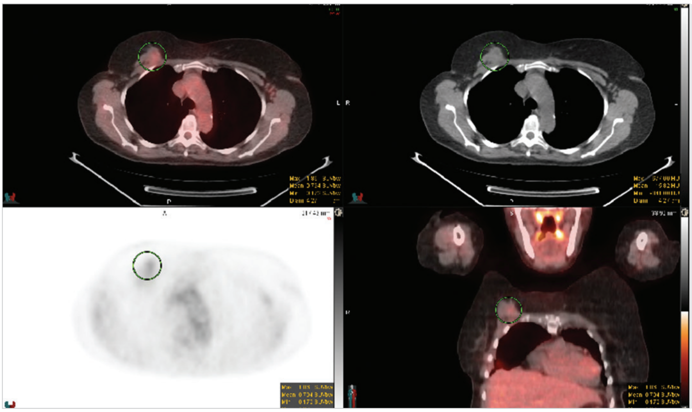

Fig. 15.5

27. What is the significance of SUV (as seen in ▶Fig. 15.6) in a breast malignancy?

a) Higher SUVs are seen in more aggressive disease.
b) Lower SUVs are seen in more aggressive disease.
c) There is no correlation of SUV with disease type.
d) Higher SUVs are seen in older patients.

27. a, higher SUVs are seen in more aggressive disease

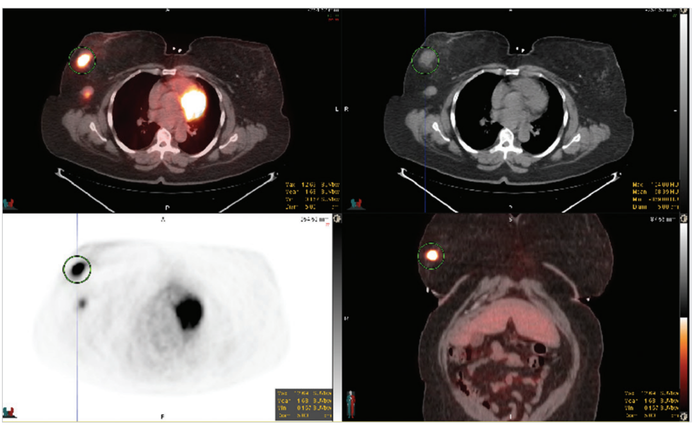

Fig. 15.6

28. What is the significance of the scan seen here (▶Fig. 15.7)?

a) Used for sentinel lymph node mapping
b) Done before surgery
c) Cannot be replaced by PET/CT
d) All of the above

28. d, all of the above

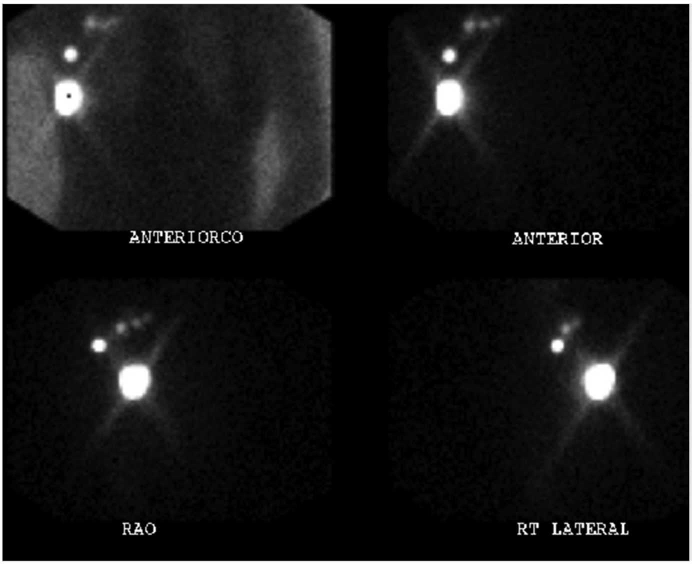

Fig. 15.7

29. What is a likely cause of this incidental breast finding in an 18-year-old woman with metastatic rhabdomyosarcoma originally in the right hand (▶Fig. 15.8)?

a) Metastatic lesion from rhabdomyosarcoma
b) Primary breast malignancy
c) Infection
d) All of the above

29. d, all of the above—although this was biopsied and found to be metastatic rhabdomyosarcoma

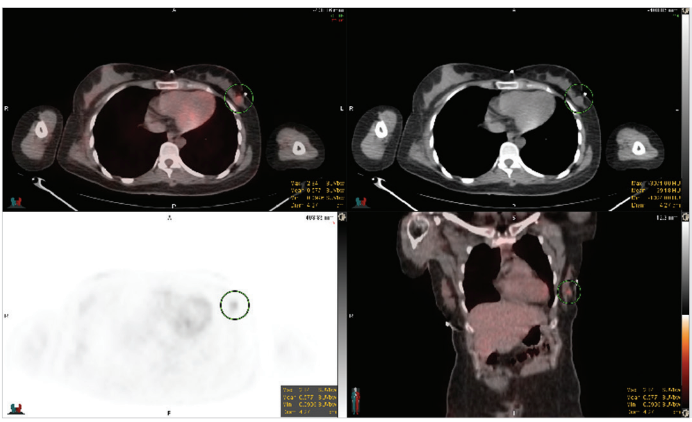

Fig. 15.8

30. What is the likely cause of this finding in a patient with left breast cancer status post surgery and chemotherapy/radiation 2 years prior (see ▶Fig. 15.9).

a) Posttreatment inflammation
b) Recurrence
c) Physiologic uptake
d) None of the above

30. b, recurrence—intense focal uptake in the region of previous disease makes recurrence highly likely

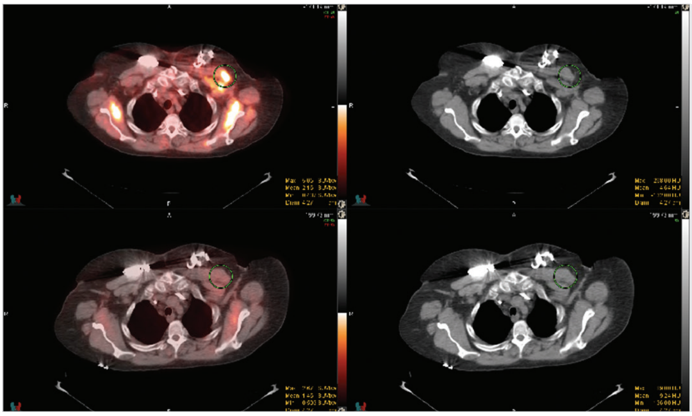

Fig. 15.9

31. What is the significance of the FDG uptake seen here (▶Fig. 15.10)?

a) Recurrence in area of prosthesis
b) Inflammation around prosthesis
c) Brown fat uptake
d) Cutaneous lymphoma

31. b, inflammation around prosthesis

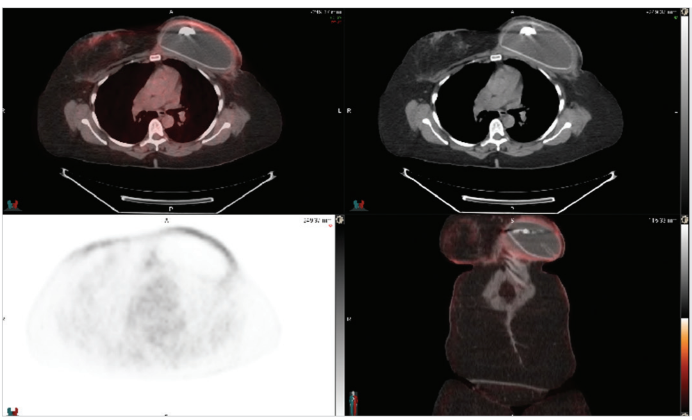

Fig. 15.10

16 Gastrointestinal

Questions

1. Which of the following statements are true concerning esophageal carcinoma? (Choose all that apply.)
   a) Esophageal carcinoma is generally detected early, due to early presentation of obstructive symptoms.
   b) The adenocarcinoma type is increasing in frequency.
   c) Squamous cell carcinoma is decreasing in frequency.
   d) Most cases are detected in the advanced stage.
   e) None of the above.
2. The best radiographic technique for detecting early esophageal carcinoma is:
   a) computed tomography (CT)
   b) endoscopic ultrasound (EUS)
   c) double contrast barium study
   d) positron emission tomography (PET)
   e) none of the above
3. The best treatment for resectable esophageal carcinoma is:
   a) surgery
   b) neoadjuvant radiation and chemotherapy, followed by surgery
   c) chemoradiotherapy
   d) none of the above
4. The current protocol for staging esophageal carcinoma includes imaging by which of the following? (Choose all that apply.)
   a) CT
   b) EUS
   c) MRI
   d) Fluorodeoxyglucose positron emission tomography (FDG-PET)
   e) None of the above

Answers

1. b, c, and d
2. c, double contrast barium study
3. b, neoadjuvant radiation and chemotherapy, followed by surgery
4. a, b, and d

5. For esophageal carcinoma, which of the following statements are true? (Choose all that apply.)
   a) Invasion of the primary tumor into the esophageal wall is best determined by EUS.
   b) Invasion of periesophageal tissues is best evaluated by EUS and CT.
   c) FDG-PET detection of primary esophageal carcinoma is more sensitive than CT detection; however, CT is more useful for initial staging of metastatic disease.
   d) FDG-PET is more sensitive than CT for the evaluation of recurrence.
   e) None of the above.

5. a, b, c, and d

6. In FDG-PET of the esophagus, which of the following statements are true? (Choose all that apply.)
   a) Reflux esophagitis exhibits an increased uptake of the FDG.
   b) Radiation-induced esophagitis demonstrates decreased uptake of the FDG.
   c) A small tumor may be a false-negative.
   d) A well-differentiated tumor may be a false-negative.
   e) None of the above.

6. a, c, and d

7. Lymph node basins that receive drainage from the esophagus include which of the following? (Choose all that apply.)
   a) Cervical nodes
   b) Mediastinal nodes
   c) Upper abdomen, including gastrohepatic and celiac nodes
   d) Axillary nodes
   e) None of the above

7. a, b, and c

8. For detection of regional nodal metastasis from esophageal carcinoma, which of the following statements are true? (Choose all that apply.)
   a) PET is more sensitive with the same specificity as CT.
   b) CT is more sensitive with the same specificity as PET.
   c) EUS is more sensitive but less specific than PET.
   d) PET is more sensitive but less specific than EUS.
   e) None of the above.

8. a and c

9. The most common sites of metastasis from esophageal carcinoma include which of the following?

a) Lung
b) Liver
c) Lymph nodes
d) Bone
e) All of the above

9. e, all of the above

10. For detecting distant metastases, which of the following statements are true? (Choose all that apply.)

a) FDG-PET is more sensitive than CT.
b) A small tumor may give a false-negative FDG-PET.
c) Inflammatory lesions may give a false-positive FDG-PET.
d) FDG-PET is more sensitive than CT plus EUS.
e) None of the above.

10. a, b, c, and d

11. Concerning a patient with esophageal carcinoma, which of the following statements are true? (Choose all that apply.)

a) A tumor with high SUV (>7) has a worse prognosis than a tumor with lower SUV.
b) No response to neoadjuvant chemoradiotherapy is associated with a worse prognosis.
c) A reduction in SUV early after initiation of neoadjuvant therapy can distinguish responders from nonresponders.
d) CT, MRI, and EUS are reliable in differentiating posttherapy scar from residual tumor.
e) None of the above.

11. a, b, and c

12. Which of the following is true regarding FDG-PET in gastric malignancy?

a) Its role in initial treatment strategy evaluation is not yet established.
b) Its role in subsequent treatment strategy evaluation is proven.
c) Gastrointestinal stromal tumors usually have lesser FDG uptake relative to gastric carcinoma.
d) Mucinous, diffuse, well-differentiated, and intestinal-type tumors have low FDG uptake.

12. d, mucinous, diffuse, well-differentiated, and intestinal-type tumors have low FDG uptake

13. In general, malignant tumors exhibit increased uptake of FDG because of which of the following? (Choose all that apply.)

a) Increased vascularity of the tumor
b) Increased cell membrane glucose transporting proteins
c) Increased intracellular hexokinase
d) None of the above

13. a, b, and c

14. The initial diagnosis of colorectal carcinoma is best accomplished by:

a) colonoscopy and biopsy
b) FDG-PET
c) CT
d) EUS
e) none of the above

14. a, colonoscopy and biopsy

15. Concerning colorectal carcinoma, FDG-PET is indicated for which of the following? (Choose all that apply.)

a) Making an initial diagnosis
b) The diagnosis and staging of recurrence
c) The differentiation of posttherapy change from recurrence
d) The characterization of indeterminate lymph node, hepatic, or pulmonary lesions as benign or malignant or initial treatment strategy evaluation for purposes of staging
e) None of the above

15. b, c, and d

16. Regarding colorectal carcinoma, which of the following statements are true? (Choose all that apply.)

a) FDG-PET is sensitive to detection of local nodal involvement.
b) CT is sensitive to detection of local nodal involvement.
c) FDG-PET is superior to CT, MRI, and ultrasound for detection of liver metastasis.
d) CT is superior to FDG-PET for detection of liver metastasis.
e) None of the above.

16. e, none of the above

17. On FDG-PET, a hypermetabolic focus in the colon may be seen in which of the following?

a) Carcinoma
b) Adenoma
c) Diverticulitis
d) Physiologic
e) All of the above

17. e, all of the above

18. For detection of colorectal recurrence and metastasis, which of the following statements are true? (Choose all that apply.)

a) CT is sensitive for detecting metastasis to peritoneum, mesentery, and lymph node.
b) FDG-PET can reliably differentiate postsurgical scar from recurrence.
c) FDG-PET is as sensitive in detecting both mucinous and nonmucinous adenocarcinoma.
d) CT is more specific than FDG-PET for detecting recurrence and metastasis.
e) None of the above.

19. Concerning FDG-PET performed after completion of radiotherapy, which of the following statements is not true?

a) A hypermetabolic focus may be due to postradiation inflammatory change.
b) A hypermetabolic focus may be due to residual tumor.
c) FDG-PET should be done no earlier than 6 weeks after completion of the therapy.
d) A hypermetabolic focus present in the radiation port 6 months after completion of therapy likely represents benign inflammatory etiology.

20. Concerning integrated PET/CT, which of the following statements are true? (Choose all that apply.)

a) There is improved lesion detection over CT alone.
b) There is improved lesion detection over PET alone.
c) It allows differentiation of physiologic from pathologic hypermetabolic foci.
d) There is better lesion localization.
e) None of the above.

21. The role of whole-body PET scan in hepatocellular carcinoma (HCC) includes all of the following except:

a) There is a limited role for ^{18}F-FDG.
b) C-11 acetate might be helpful.
c) Two-thirds of ^{18}F-FDG-PET scans are falsely negative.

18. b, FDG-PET can reliably differentiate postsurgical scar tissue from recurrence

19. d, a hypermetabolic focus present in the radiation port 6 months after completion of therapy likely represents benign inflammatory etiology

20. a, b, c, and d

21. c, two-thirds of ^{18}F-FDG-PET scans are falsely negative

22. Which of the following is true regarding ^{18}F-FDG uptake in the gastrointestinal tract and abdomen?

a) Diffuse bowel uptake may be secondary to metformin use.
b) Diffuse splenic uptake may be seen after chemotherapy.
c) Diffuse gastric uptake can be due to gastritis.
d) All of the above.
e) None of the above.

23. What is the observed finding likely due to ▶Fig. 16.1?

a) Colon cancer
b) Metformin use
c) Physiologic uptake
d) b or c

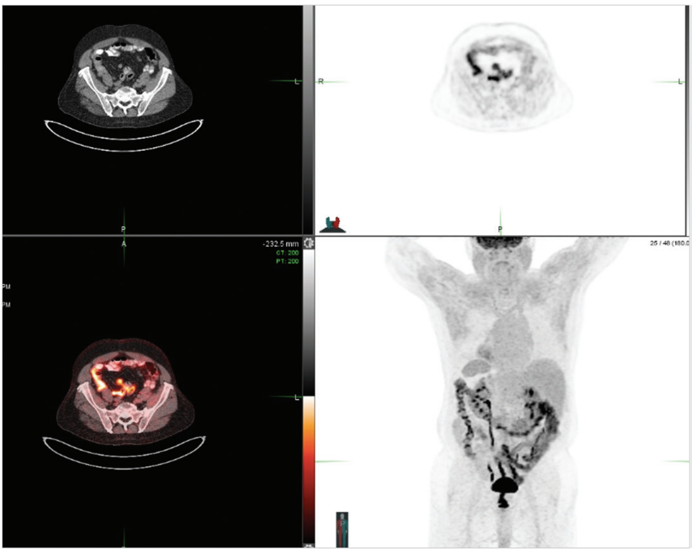

Fig. 16.1

24. Patient with head and neck malignancy presents with the following finding (▶Fig. 16.2).

What is the most likely cause?

a) Esophageal cancer
b) Esophagitis
c) Metastases
d) None of the above

22. d, all of the above

23. d

24. b, esophagitis—mild diffuse uptake with no obvious CT abnormality makes esophagitis most likely

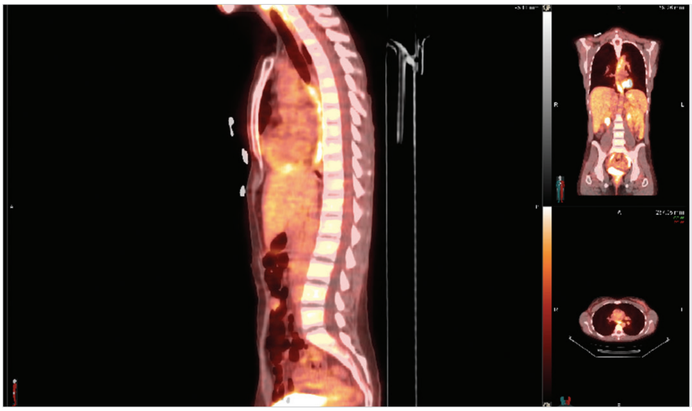

Fig. 16.2

25. Patient with history of colon cancer status post surgery 1 year prior has the following presentation (▶Fig. 16.3).

What is the etiology of the findings seen here?

a) Postsurgical change
b) Recurrence
c) Physiologic tracer in bowel
d) Infection

25. b, recurrence—uptake in region of sutures as well as a mesenteric soft-tissue nodule makes recurrence highly likely. Postsurgical change should resolve in a few months.

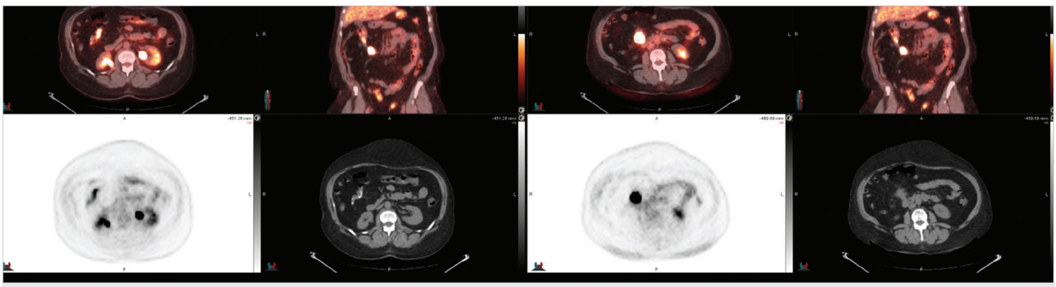

Fig. 16.3

26. Patient with dysphagia has the following finding on PET scan (▶Fig. 16.4).

What is the likely cause?

a) Esophageal adenocarcinoma
b) Esophagitis
c) Infection
d) Physiologic uptake

26. a, esophageal adenocarcinoma—esophageal wall thickening with intense focal uptake at the gastroesophageal junction make malignancy highly likely

27. Patient with treated esophageal cancer has only the following finding on their scan (▶Fig. 16.5).

What is the likely cause?

a) Metastatic lymph node
b) Reactive lymph node
c) Lymphoma
d) None of the above

27. b, reactive lymph node—in the absence of any other findings, this mildly avid nonenlarged hilar lymph node is likely reactive. FDG-avid reactive hilar lymph nodes are a very common finding

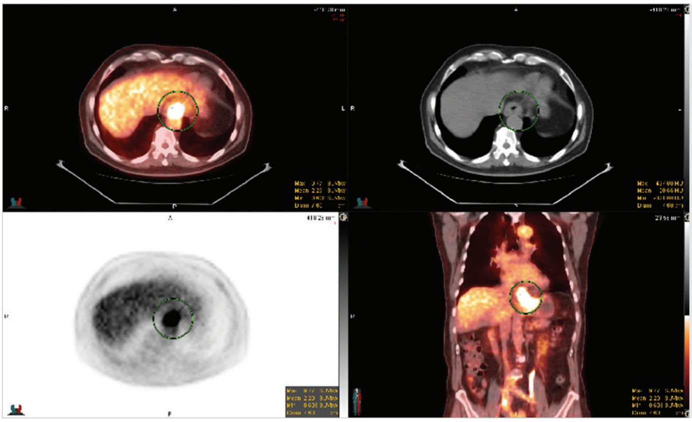

Fig. 16.4

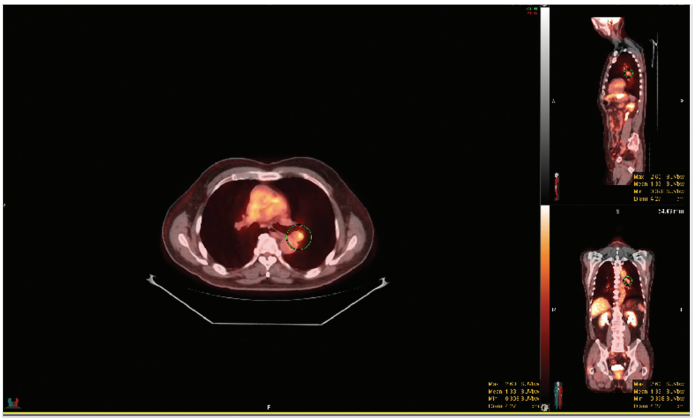

Fig. 16.5

28. What is the finding identified most likely due to (▶Fig. 16.6)?

a) Pancreatitis
b) Pancreatic adenocarcinoma
c) Physiologic pancreatic uptake
d) Metastasis from another primary

28. b, pancreatic adenocarcinoma–the presence of an FDG-avid mass within the pancreas makes this the most likely etiology

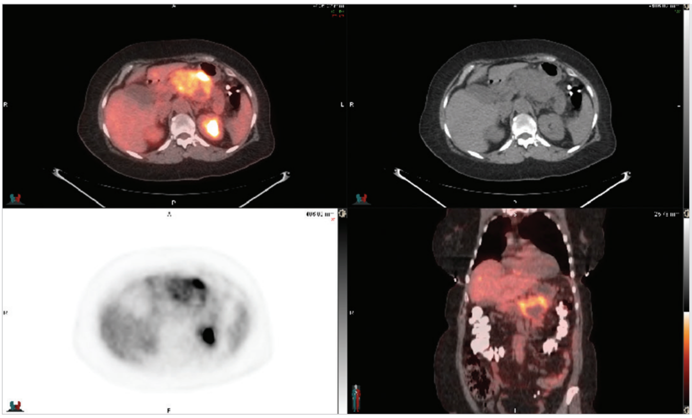

Fig. 16.6

29. Patient with known HCC presents with the following scan (▶Fig. 16.7).

What is the most likely reason for this finding?

a) Patient does not have disease
b) HCC can be falsely negative on PET scan
c) HCC has a high rate of gluconeogenesis
d) B and C

29. b and c

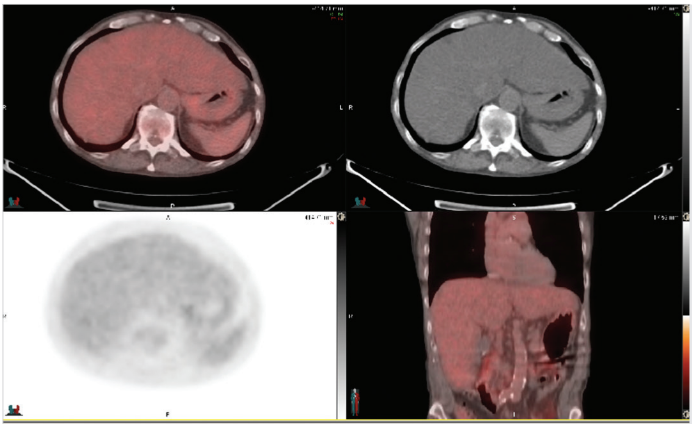

Fig. 16.7

30. What is the true about the finding on this scan (▶Fig. 16.8)?

a) Caused by liver metastases
b) Caused by attenuation artifact
c) Heterogeneous FDG uptake may obscure subtle lesions
d) B and C

30. d

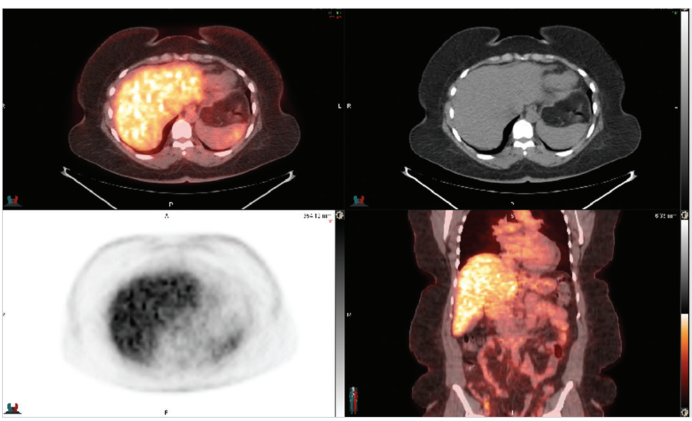

Fig. 16.8

31. Patient with weight loss, abdominal pain, and the following finding (▶ Fig. 16.9).

What is the most likely etiology?

a) Gastric cancer
b) Gastritis
c) Infection
d) Physiologic uptake

31. a, gastric cancer—gastric wall thickening with intense focal uptake make gastric cancer the most likely etiology

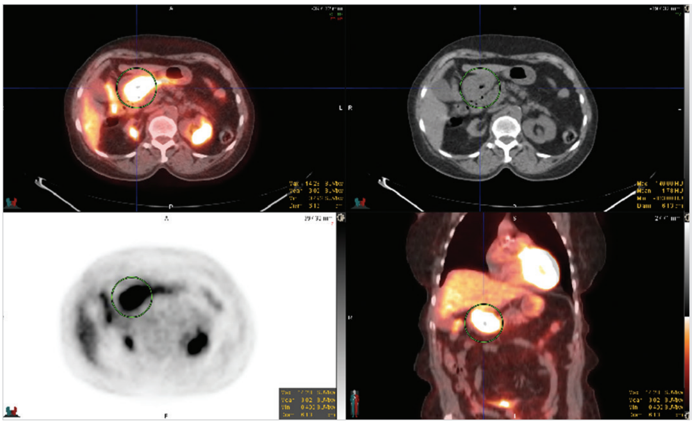

Fig. 16.9

32. Patient with history of colon cancer status post resection (▶ Fig. 16.10).

What is the finding seen here?

a) Physiologic tracer in region of sutures
b) Recurrence
c) Infection
d) Inflammatory bowel disease

32. a, physiologic tracer in the region of sutures—very minimal FDG uptake with no CT correlate makes this most likely to be physiologic

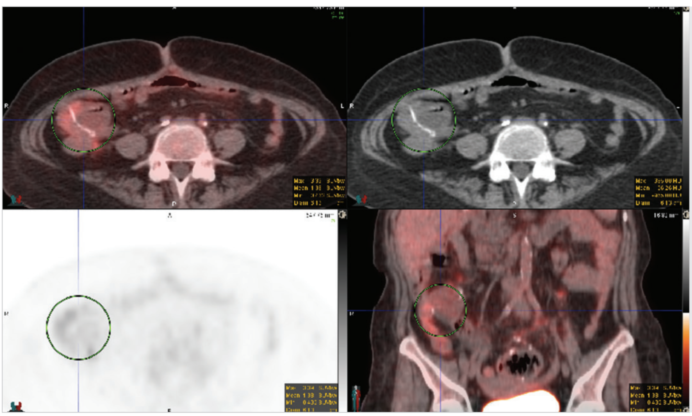

Fig. 16.10

17 Pulmonary

Questions

1. In a patient with a pulmonary nodule characterized as having a high likelihood for malignancy by computed tomography (CT), the next procedure of choice is:
   a) positron emission tomography/ computed tomography (PET/CT) with fluorodeoxyglucose (FDG)
   b) transthoracic needle aspiration or video-assisted thoracoscopy with wedge resection
   c) follow-up with chest CT at frequent intervals (every 3 months) for 2 years
2. If a patient who is at high risk for procedure-related morbidity or mortality has a pulmonary nodule characterized as having a low likelihood for malignancy by CT, the next procedure of choice is:
   a) PET/CT with FDG
   b) CT follow-up at frequent intervals (3 months)
   c) transthoracic needle aspiration or video-assisted thoracoscopy with wedge resection
3. In a patient with a nodule characterized by CT as indeterminate for malignancy, the next procedure of choice is:
   a) PET/CT with FDG
   b) CT follow-up at frequent intervals (3 months)
   c) transthoracic needle aspiration or video-assisted thoracoscopy with wedge resection

Answers

1. b, transthoracic needle aspiration or video-assisted thoracoscopy with wedge resection
2. a, PET/CT with FDG
3. a, PET/CT with FDG

4. For a given pulmonary nodule identified on FDG-PET, which of the following statements are true? (Choose as many as apply.)

a) Hyperintensity relative to the mediastinal background is considered malignant.
b) Hypointensity relative to the mediastinal background is considered malignant.
c) Hypointensity relative to the mediastinal background is considered benign.
d) None of the above.

4. d, none of the above

5. When the standard uptake value (SUV), a semi-quantitative measurement of FDG uptake, is evaluated, what is the general cut-off value for differentiation between a benign and a malignant pulmonary nodule?

a) 2.0
b) 2.5
c) 3.0
d) 3.5
e) 4.0

5. b, 2.5

6. Which of the following diseases can produce a false-positive result from a granulomatous lesion in oncologic FDG-PET? (Choose as many as apply.)

a) Tuberculosis
b) Aspergillosis
c) Histoplasmosis
d) Sarcoidosis

6. a, b, c, d

7. False-negative FDG-PET commonly occurs in which of the following malignancies? (Choose as many as apply.)

a) Adenocarcinoma in situ
b) Mucinous adenocarcinoma
c) Squamous cell carcinoma
d) Bronchial carcinoid

7. a, b, d

8. True or false: Due to partial volume averaging, a nodule smaller than 7 mm exhibiting an SUV lower than the cut-off value of 2.5 cannot be considered benign.

8. True.

9. True or false: With a pulmonary nodule larger than 1 cm and an SUV below the cut-off point of 2.5, a malignancy is essentially excluded.

9. False.

10. True or false: A negative FDG-PET essentially excludes high-grade lung carcinoma.

10. True.

11. True or false: Approximately 5 to 10% of pulmonary nodules that are negative on FDG-PET turn out to be malignant.

12. An acceptable approach to a pulmonary nodule with a low SUV is to:
   a) repeat the PET scan in 3 months.
   b) follow up with dedicated CT scans to evaluate interval growth for at least 2 years.
   c) perform early and delayed dual-phase FDG-PET to evaluate changes in the SUV.
   d) nothing needs to be done; the nodule is likely benign.

13. A 5-mm pulmonary nodule should be followed up with:
   a) PET/CT scan
   b) CT scan
   c) biopsy
   d) magnetic resonance imaging (MRI)

14. The imaging modalities accepted for staging lung carcinoma include which of the following? (Choose all that apply)
   a) FDG-PET/CT
   b) CT
   c) MRI of the brain
   d) Ultrasound

15. True or false: In a patient with lung carcinoma, a CT scan can rarely differentiate between reactive and malignant effusion.

16. True or false: In a patient with lung carcinoma, FDG uptake in pleural space is worrisome for malignant effusion.

17. True or false: In staging nodal disease in lung carcinoma, FDG-PET/CT is more sensitive and specific than CT.

18. True or false: Approximately 15% of nodal metastases are in normal-size lymph nodes.

19. True or false: If PET is normal in the mediastinum in a patient with lung carcinoma, generally it can be assumed that the patient is free of mediastinal lymph node metastasis (high sensitivity).

20. True or false: If PET revealed a positive mediastinal node, then most likely the node is metastatic, and diagnostic mediastinoscopy is unnecessary.

11. True.

12. b, follow up with dedicated CT scans to evaluate interval growth for at least 2 years

13. b, CT scan

14. a, b, c

15. True.

16. True.

17. True.

18. True.

19. True.

20. False.

21. True or false: Common sites of metastases in lung carcinoma include the lungs, brain, adrenal glands, and bone; liver and soft tissues are less common.

22. True or false: CT and MRI are superior to PET in detecting brain metastasis.

23. True or false: Some brain metastasis may appear as a photopenic area on FDG-PET secondary to vasogenic edema rather than as a hyperintense focus from the metastatic tumor itself.

24. True or false: For adrenal metastasis, CT is superior to PET.

25. True or false: A bone scan with ^{99m}Tc–methylene diphosphate (MDP) is more sensitive than FDG-PET in detecting bone metastasis from lung carcinoma.

26. True or false: The absence of uptake of FDG in a residual tumor mass after therapy is associated with a good prognosis.

27. True or false: Hypermetabolic activity in a residual tumor mass following therapy implies a residual viable tumor.

28. True or false: Diffuse low- to intermediate-grade hypermetabolism in radiation ports up to 3 to 6 months after radiotherapy is likely due to radiation pneumonitis.

29. True or false: The uptake of FDG correlates with tumor grade: the higher the grade of the tumor, the higher the FDG uptake. When the intensity of FDG uptake increases, the survival rate decreases.

30. Which of the following best describes the current Centers for Medicare & Medicaid Services (CMS) national coverage of FDG-PET/CT in small cell lung cancer (SCLC) and non-small-cell lung cancer (NSCLC)?

a) SCLC is covered for initial treatment strategy but not covered for subsequent treatment strategy.
b) Both SCLC and NSCLC are covered for initial and subsequent treatment strategies.
c) Only NSCLC is covered for both initial and subsequent treatment strategies.
d) FDG-PET/CT for subsequent treatment strategy in SCLC is covered only through entry into National Oncologic PET Registry (NOPR).

21. True.

22. True.

23. True.

24. False.

25. False.

26. True.

27. True.

28. True.

29. True.

30. b

31. Name some causes of false-positive lung findings on a PET/CT scan.

31. Infectious and inflammatory conditions such as pneumonia, pneumonitis, mycobacterial disease, fungal diseases, rheumatoid nodules, sarcoidosis

32. Name some causes of false-negative lung findings on a PET/CT scan.

32. Well-differentiated tumors, adenocarcinoma in situ, minimally invasive adenocarcinoma, mucinous adenocarcinoma, carcinoid, size less than 1 cm, uncontrolled hyperglycemia

33. Which of the following facts are true regarding lung cancer?

a) It is the second most common cancer in both men and women.
b) The average age at the time of diagnosis is about 50.
c) Lung cancer is the leading cause of cancer death among both men and women.
d) Survival varies depending on the stage of the cancer when it is diagnosed.

33. a, c, d

34. Which of the following are true regarding the staging of lung cancer?

a) T1, less than 3 cm (a and b); T2, 3 to 7 cm (a and b); T3, greater than 7cm/ invasion/tumor less than 2 cm distal to carina/atelectasis or obstructive pneumonitis of the entire lung/additional tumor nodules in same lobe; T4, additional tumor nodules in ipsilateral lobes
b) N1, ipsilateral hilar and peribronchial lymph nodes; N2, ipsilateral mediastinal; N3, contralateral mediastinal/hilar nodes or supraclavicular nodes on any side
c) M1, pleural/pericardial nodules and effusions/additional nodules in contralateral lung; M1b, distant metastatic disease

34. a, b, c

35. Which of the following is true in regard to lung cancer imaging? (Choose all that apply.)

a) FDG-PET/CT is the best imaging tool for prognosis and staging.
b) Contrast-enhanced CT is the best imaging tool to evaluate for brain metastasis.
c) No imaging tool is specific to defer lymph node biopsy if required for treatment planning.
d) FDG-PET/CT is the best modality to detect lymphangitic carcinomatosis.

35. a, c

36. True or false: A cut-off of 2.5 has been established for SUV max of lung nodules to discriminate between benign and malignant etiology.

Questions 37 through 40. Regarding management of solitary pulmonary nodule, mark true or false for each of the response choices:

37. FDG-PET/CT is not recommended if a solitary pulmonary nodule (SPN) has a high probability of malignancy (> 60%) or the nodule is less than 8 to 10 mm.

38. Nodule with suspicious CT morphology should be biopsied even with negative FDG-PET.

39. FDG-avid nodule should be biopsied only if there is documented growth on follow-up CT.

40. Ground-glass pulmonary nodules have low FDG avidity.

41. Axial fused FDG-PET/CT image demonstrates no increased metabolic activity in right upper lobe SPN, suggesting a benign process (▶Fig. 17.1). False-negative results for SPN characterization on FDG-PET/CT can occur due to: (choose all that apply)

a) hyperglycemia
b) low tumor metabolic activity
c) small lesion size
d) delayed imaging

Fig. 17.1

36. False. (A cut-off of 2.5 was established for SUV mean.)

37. True.

38. True.

39. False.

40. True.

41. a, b, c

42. Fused axial FDG-PET/CT image in a 65-year-old woman shows a slowly growing sub-solid mass in the upper lobe of the right lung demonstrating mildly increased FDG activity (SUV max 2.4) (▶ Fig. 17.2).

The most likely diagnosis is:

a) scar
b) poorly differentiated squamous cell carcinoma
c) well-differentiated carcinoid
d) adenocarcinoma

Fig. 17.2

42. d

43. Fused axial FDG-PET/CT image in a 76-year-old woman shows bilateral pulmonary masses and nodules demonstrating moderate FDG avidity (▶ Fig. 17.3).

Which of the following is true regarding multifocal adenocarcinoma? (Choose all that apply)

a) Approximately 70% bilateral
b) Slow rate of growth and progression
c) Increased prevalence in women and nonsmokers
d) Associated with longer median survival

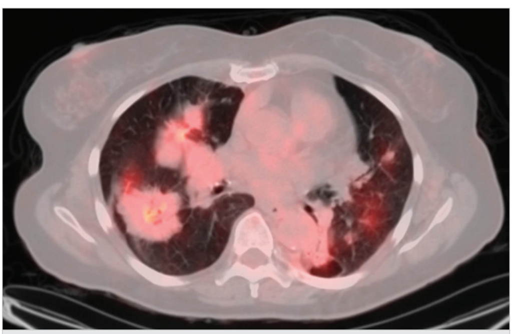

Fig. 17.3

43. b, c, d

44. Fused axial FDG-PET/CT image in a 65-year-old woman shows an FDG-avid cavitary lung mass (▶Fig. 17.4).

Which is the most common histological type of lung cancer to cavitate?

a) Adenocarcinoma
b) Small cell lung cancer
c) Squamous cell carcinoma
d) Lymphoma

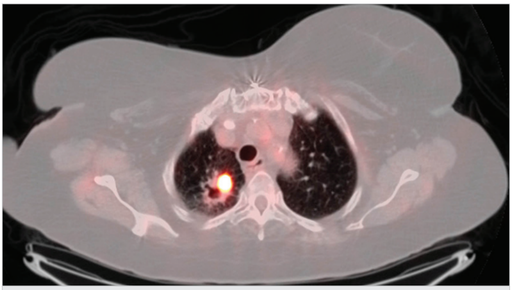

Fig. 17.4

44. c

45. Fused axial FDG-PET/CT image through the brain of a patient with lung cancer is shown (▶Fig. 17.5).

Which of the following statements are true?
(Choose all that apply)

a) This is stage IV lung cancer.
b) PET/CT imaging is standard of care for evaluation of brain metastasis.
c) 90% of the brain metastases are easily detectable on FDG-PET images.
d) Brain metastasis can be hypermetabolic, isometabolic, or hypometabolic compared to the cortex.

45. a, d

46. You are shown selected image from FDG-PET/CT obtained for staging of cancer (▶Fig. 17.6).

Which of the following is (are) true in regard to FDG-PET/CT imaging in lung cancer?
(Choose all that apply)

a) Detects response to treatment accurately and predicts prognosis
b) Necrotic masses demonstrate homogeneous FDG uptake
c) Best imaging modality for detection of brain metastases
d) Can change management depicting occult disease

46. a, d

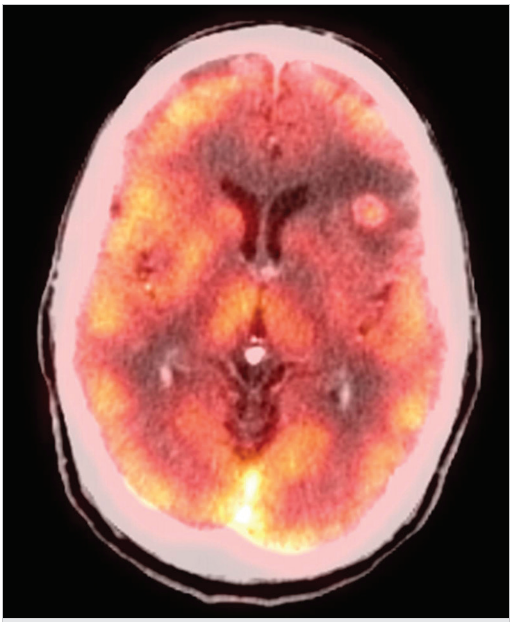

Fig. 17.5

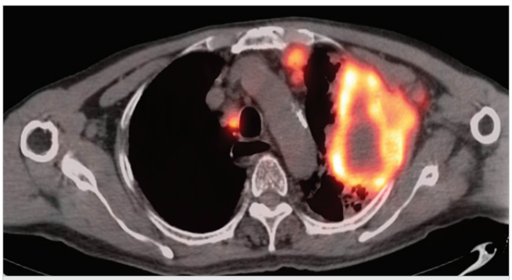

Fig. 17.6

47. You are shown selected axial and maximum intensity projection FDG-PET/CT images in a 55-year-old man (▶Fig. 17.7).

Main differential considerations for this case include:
(choose all that apply)
a) mesothelioma
b) lymphoma
c) benign fibrous tumor of the pleura
d) malignant thymoma

47. a, b, d

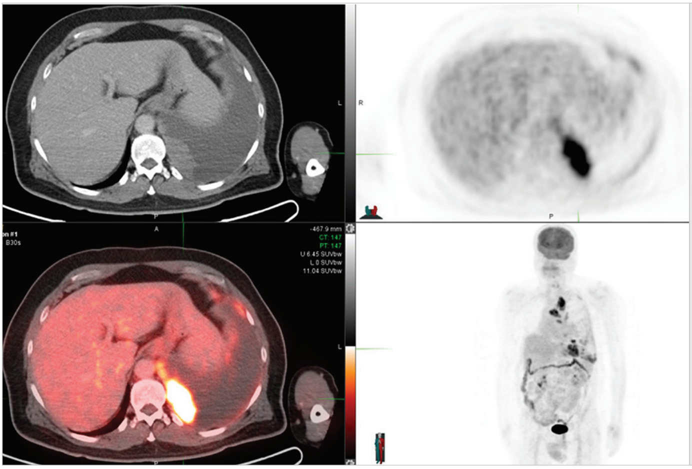

Fig. 17.7

48. You are shown fused axial FDG-PET/CT images in a patient who underwent chemotherapy and radiation therapy for small cell lung cancer 2 years ago (▶Fig. 17.8a, b).

The images demonstrate evidence for: (choose all that apply)

a) left vocal cord palsy
b) right vocal cord tumor lesion
c) postradiation pneumonitis
d) recurrent lung cancer

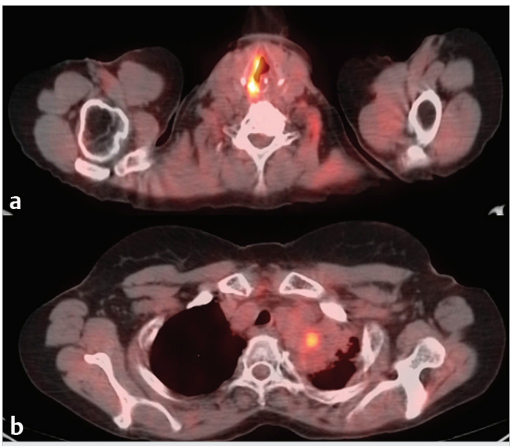

Fig. 17.8

48. a, d

49. You are shown FDG-PET/CT images from three different patients with the same disease (▶Fig. 17.9a–c).

Which is the most likely diagnosis?

a) Lymphoma
b) Sarcoid
c) Small cell lung cancer
d) Aspergillosis
e) Non–small cell lung cancer

49. b

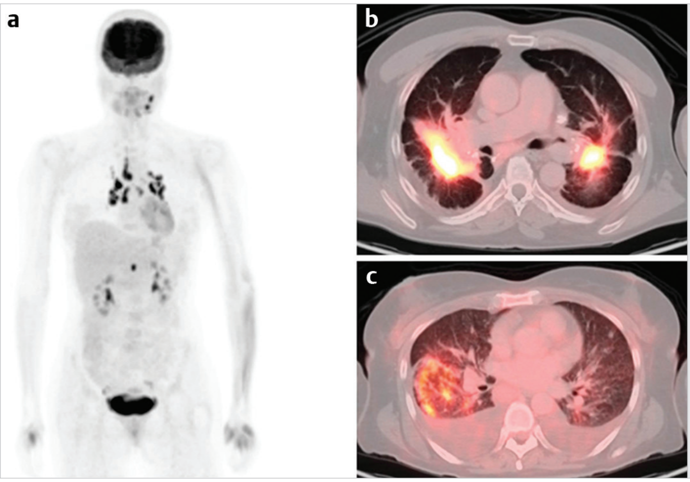

Fig. 17.9

50. You are shown FDG-PET/CT images of a patient with small cell lung cancer (SCLCA) (▶Fig. 17.10a–c).

Which of the following statements regarding SCLCA are correct?
(Choose all that apply)

a) Frequently presents as a solitary parenchymal pulmonary nodule
b) Occurs centrally in approximately 90%
c) May appear similar to lymphoma on imaging with mediastinal involvement
d) SCLCA is the most common cause of superior vena cava obstruction

50. b, c, d

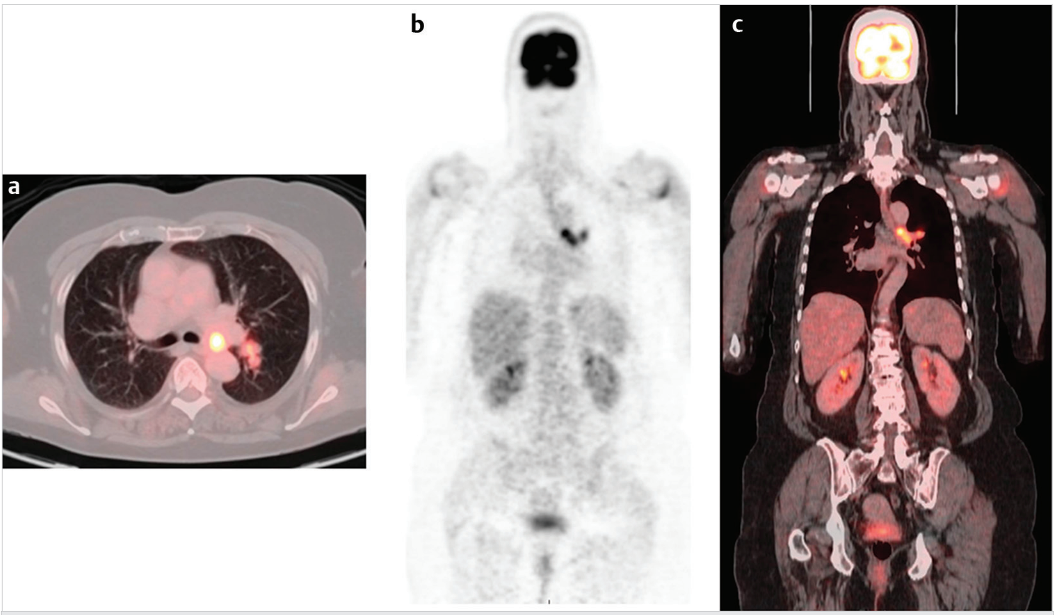

Fig. 17.10

18 Genitourinary

Questions

1. Which of the following statements concerning renal cell carcinoma (RCC) imaging are true? (Choose all that apply.)
   a) Fluorodeoxyglucose positron emission tomography (FDG-PET) is positive in RCC, angiomyolipoma, pericytoma, and pheochromocytoma.
   b) Computed tomography (CT) is the imaging modality of choice for diagnosis and staging of RCC.
   c) The degree of confidence in the diagnosis with magnetic resonance imaging (MRI) is similar to that of contrast-enhanced CT.
   d) FDG-PET may be used to monitor therapy.
2. Which of the following statements concerning prostate carcinoma is (are) true? (Choose all that apply.)
   a) Most primary prostate carcinomas demonstrate low uptake of FDG.
   b) FDG-PET can reliably differentiate carcinoma from benign prostate hypertrophy.
   c) FDG-PET is sensitive for lymph node metastasis.
   d) FDG-PET is more sensitive than a bone scan in detecting sclerotic bone metastasis.
3. Which of the following statements concerning prostate carcinoma is (are) true? (Choose all that apply.)
   a) A PET bone scan with ^{18}F-fluoride is more sensitive than a ^{99m}Tc–methylene diphosphate (MDP) bone scan.
   b) Choline PET with ^{11}C or ^{18}F is more accurate than FDG-PET for local recurrence and nodal and distant metastasis.
   c) Most prostate carcinomas require androgen for growth and metastasis.
   d) FDG-PET is useful for monitoring response to therapy.
   e) None of the above.

Answers

1. a, b, c, and d
2. a, most primary prostate carcinomas demonstrate low uptake of FDG
3. a, b, c, and d

4. What nuclear imaging can be performed for prostate cancer? (Choose all that apply.)

a) ^{18}F-FDG-PET/CT
b) ^{11}C acetate/^{11}C choline (short half-life limits its use to centers with on-site production capability)
c) ^{99m}Tc-MDP bone scan (for initial staging and recurrent disease with prostate specific antigen [PSA] greater than 10 ng/mL)
d) Fluciclovine (^{18}F) (Axumin) PET/CT (suspected recurrent prostate cancer based on elevated PSA)

4. a, b, c, and d

5. Regarding PET/CT imaging in prostate cancer, which of the following is (are) true?

a) FDG-PET has low sensitivity for primary prostate cancers, lymph node metastasis, and bone metastases.
b) FDG-PET/CT is not covered for initial treatment strategy evaluation.
c) Histologically confirmed diagnosis is not required prior to FDG-PET scan for prostate cancer.
d) The probability of pelvic lymph node metastases does not correlate with the PSA level or the Gleason score

5. a and b

6. Which of the following statements concerning bladder carcinoma is (are) true? (Choose all that apply.)

a) Physiologically excreted ^{18}F-FDG in the bladder limits evaluation of bladder tumors.
b) FDG-PET is useful in detecting tumor recurrence in the pelvis.
c) FDG-PET is useful in differentiating postoperative scar tissue from local recurrence.
d) FDG-PET is useful for detection of distant metastasis.
e) None of the above.

6. a, b, c, and d

7. Which of the following statements concerning cervical carcinoma is (are) true? (Choose all that apply.)

a) Cervical carcinoma has a low uptake of FDG.
b) FDG-PET is useful in initial diagnosis and in detecting nodal involvement.
c) FDG-PET has been proven to be superior to CT or MRI in detecting metastasis.
d) FDG-PET is useful for monitoring therapeutic response.

7. b, c, and d

8. Which of the following statements regarding the current status of coverage for FDG-PET scans in cervical cancer is (are) true?

a) It is covered for subsequent treatment strategy.
b) It is not covered for diagnosis.
c) It is covered for initial treatment strategy with a negative CT/MRI for extra-pelvic metastatic disease.
d) It is covered for diagnosis and subsequent treatment strategy.

8. a, b, and c

9. FDG hypermetabolic activity is seen in:

a) endometrial carcinoma and sarcoma
b) most uterine myoma
c) physiologic endometrial uptake during ovulatory and menstrual phases
d) functional cysts
e) all of the above

9. a, c, and d

10. Which of the following statements concerning ovarian carcinoma are true? (Choose all that apply.)

a) A serum tumor marker such as carbohydrate antigen (CA-125) is useful in diagnosis.
b) In premenopausal women, high uptake of FDG in ovaries is related to the menstrual cycle.
c) FDG-PET is sensitive in detecting peritoneal micrometastasis.
d) A negative FDG-PET can obviate second-look surgery.
e) None of the above.

10. a and b

11. True or false: FDG-PET is helpful in differentiating local tumor recurrence from postoperative and/or postradiation changes.

11. True.

12. True or false: FDG uptake in normal testis is variable.

12. True.

13. True or false: Serum tumor markers (α-fetoprotein and human chorionic gonadotropin [HCG]) are sensitive for detection of testicular tumors.

14. True or false: Seminoma tends to accumulate more FDG than nonseminoma.

15. True or false: FDG-PET is less accurate than CT in restaging testicular tumor.

16. Which of the following statements concerning testicular carcinoma are true? (Choose all that apply.)

a) FDG-PET is superior to CT in initial diagnosis and staging.
b) FDG-PET is better than CT in monitoring therapeutic response.
c) Posttherapy inflammation increases FDG uptake.
d) FDG-PET reliably differentiates posttherapy fibrosis from residual tumor.
e) None of the above.

17. An 84-year-old woman with bladder cancer underwent FDG-PET/CT for initial staging. Axial CT, PET, and fused PET/CT images and a maximum intensity projection (MIP) image are shown (▶Fig. 18.1).

Which of the following statements concerning FDG-PET imaging of bladder cancer are true? (Choose all that apply.)

a) Bladder cancer typically has high FDG avidity.
b) The initial diagnostic workup of bladder cancer includes cystoscopy and biopsy and FDG-PET/CT as principal staging modality.
c) Immediate postvoid imaging and intravenous administration of Lasix with parenteral hydration can improve the bladder cancer detection.
d) FDG-PET is useful for preoperative staging, treatment response assessment, and distinguishing posttreatment change from tumor recurrence.

13. True.

14. True.

15. False.

16. b, c, and d

17. c and d

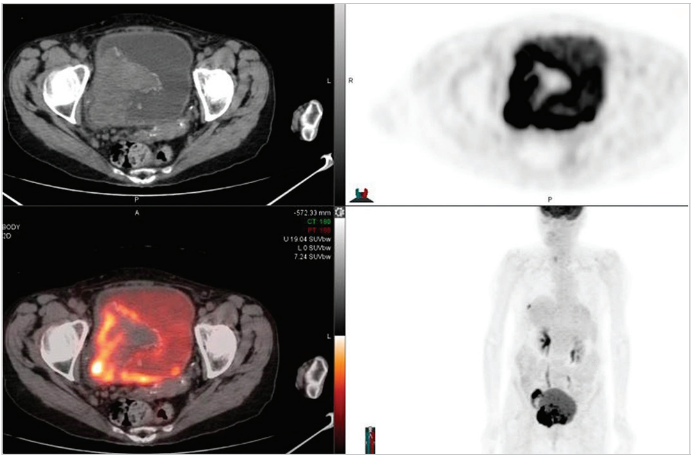

Fig. 18.1

18. A 73-year-old man with stage IV prostate cancer and rising PSA concerning for progression of disease underwent FDG-PET/CT. Fused coronal PET/CT image is shown (▶Fig. 18.2).

Which of the following statements concerning FDG-PET sensitivity for detection of skeletal metastasis are true? (Choose all that apply.)

a) FDG-PET is more sensitive than a conventional bone scan in detecting sclerotic bone metastasis.
b) FDG-PET is more sensitive than a conventional bone scan in detecting lytic bone metastasis.
c) FDG-PET is more sensitive than a sodium fluoride (NaF) PET in detecting sclerotic bone metastasis.
d) FDG-PET is more sensitive than an NaF PET in detecting lytic bone metastasis.

19. A 60 year-old woman on chemotherapy for endometrial cancer underwent FDG-PET/CT (▶Fig. 18.3a–c).

Which of the following statements regarding FDG-PET/CT utilization in endometrial cancer and the results of this test are correct? (Choose all that apply.)

a) FDG-PET/CT is superior to MRI for evaluation of the extent of the primary tumor.
b) FDG-PET/CT improves the detection of distant metastatic disease.
c) FDG-PET/CT is superior to conventional imaging for detecting lymph node metastases.
d) FDG-PET/CT has approximately 95% sensitivity and 80% specificity for posttherapy restaging.
e) The patient has stage IV cancer.

18. b and d

19. b, c, d, and e

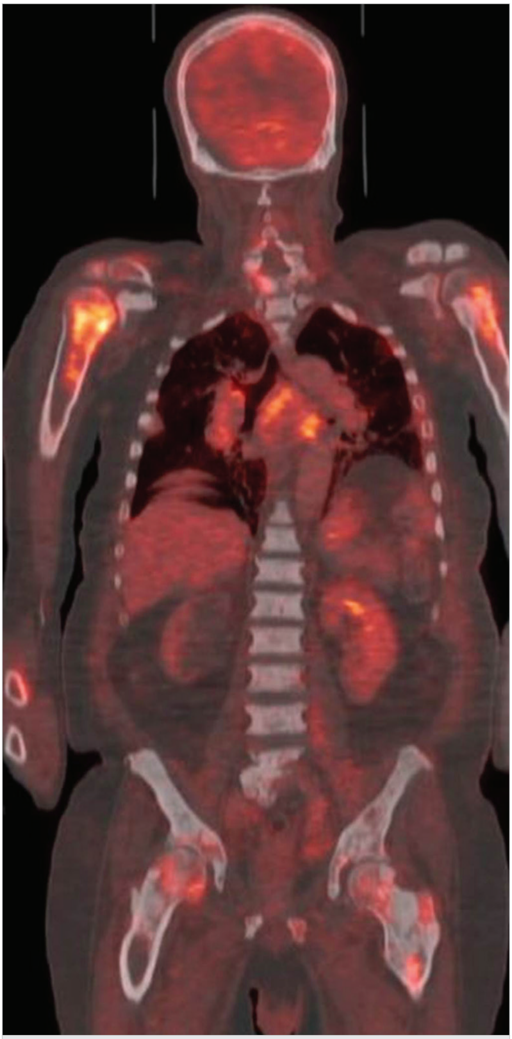

Fig. 18.2

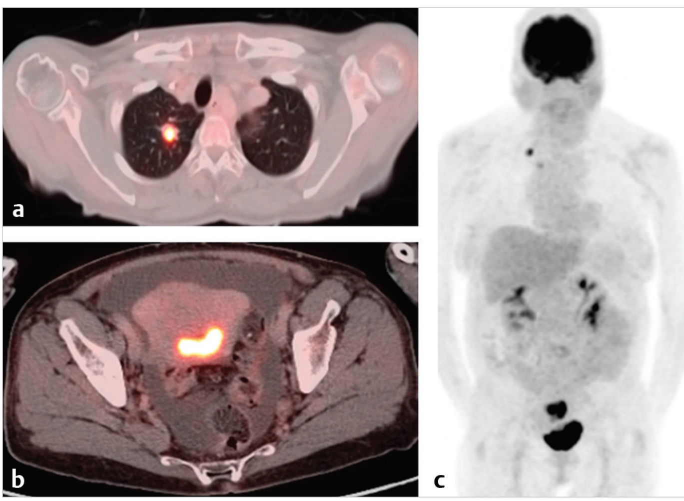

Fig. 18.3

20. Selected images from an FDG-PET/CT study in a 60-year-old woman with history of previously treated cervical cancer are shown (▶Fig. 18.4a–c).

Which of the following statements regarding FDG-PET/CT utilization in recurrent cervical cancer are true?

a) Patients with rising tumor markers and negative conventional imaging studies can benefit from FDG-PET imaging.
b) FDG-PET has limitation distinguishing recurrent disease from postradiation changes.
c) FDG-PET imaging has approximately 90% sensitivity and 76% specificity for detection of early recurrence of cervical cancer.
d) Both squamous cell and adenocarcinoma of the cervix demonstrate FDG avidity.

20. a, c, and d

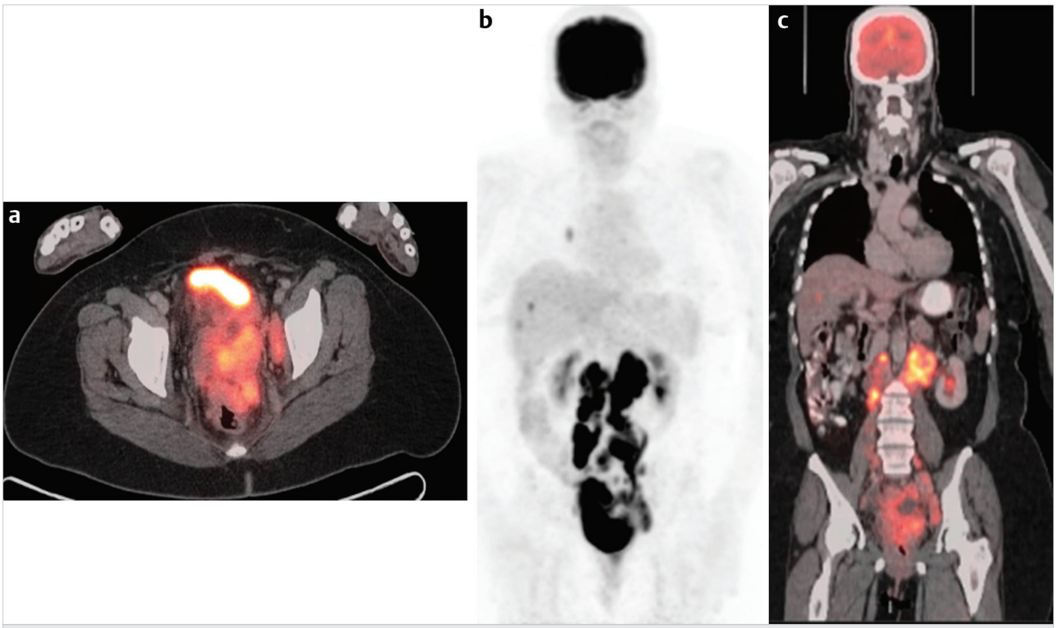

Fig. 18.4

21. Selected axial CT and fused FDG-PET/CT images in a 38-year-old woman are shown (▶Fig. 18.5a, b).

True statements regarding FDG-PET uptake in the ovaries include which of the following? (Choose all that apply.)

a) Increased FDG uptake in the ovaries can be functional or malignant in a premenopausal patient.
b) Corpus luteal cysts are rare.
c) FDG uptake in a corpus luteal cyst is transient.
d) Information about the patient's menstrual status is not contributory for the interpretation of the FDG-PET.

21. a and c

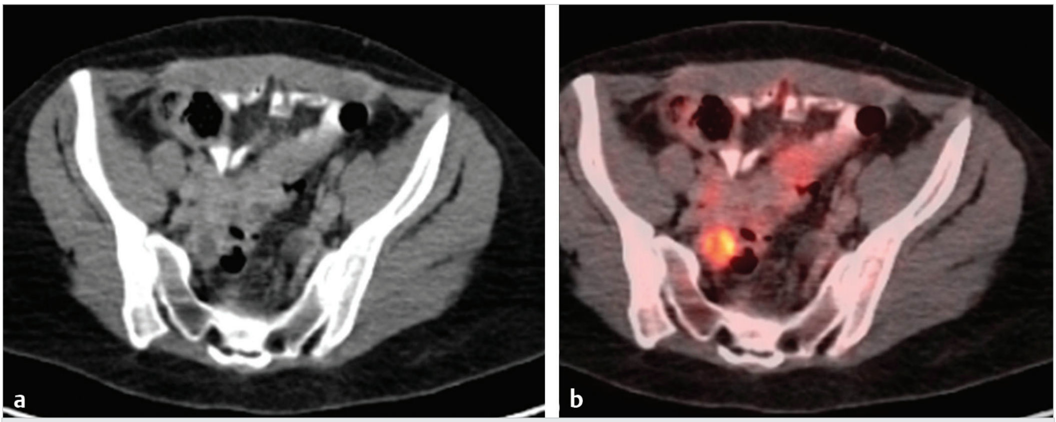

Fig. 18.5

22. Selected fused axial section from FDG-PET/CT study in a 45-year-old woman showed incidental uterine mass (▶Fig. 18.6).

True statements regarding uterine leiomyoma imaging include which of the following? (Choose all that apply.)

a) Mild or moderate FDG uptake is often observed in uterine leiomyoma.
b) Degenerated uterine leiomyomas tend to have higher FDG uptake.
c) FDG-PET imaging can reliably differentiate between benign leiomyoma and uterine sarcoma.
d) MRI is the preferred imaging modality for accurate characterization of uterine leiomyoma.

22. a, b, and d

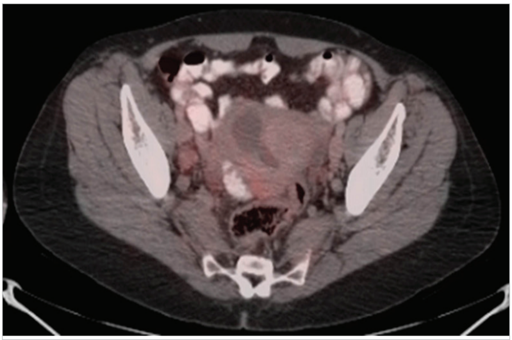

Fig. 18.6

23. You are shown a selected axial fused image from an FDG-PET/CT study in a 68-year-old woman with history of cervical cancer and radical hysterectomy (▶Fig. 18.7).

Which of the following statements regarding the FDG-PET application in cervical cancer are correct? (Choose all that apply.)

a) The maximum standard uptake value of the primary tumor is predictive of disease outcome.
b) FDG-PET has high accuracy in assessment of local recurrence and distant metastatic disease.
c) Posttherapy FDG-PET is predictive of survival.
d) FDG-PET is superior to MRI for evaluation of the extent of the primary tumor.

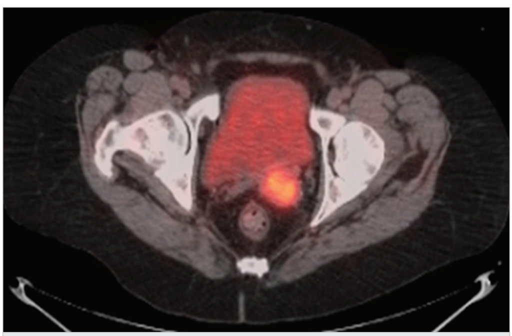

Fig. 18.7

23. a, b, and c

24. You are shown selected axial fused FDG-PET/CT images in a 42-year-old woman (▶Fig. 18.8a, b).

Which one of the following is the best interpretation of the images?

a) FDG uptake in the uterus due to menstruation, uterine fibroid, corpus luteum cyst.
b) Cervical cancer, metastatic right iliac lymph node, uterine fibroids.
c) Ovarian cancer, metastatic lesion in the uterus, uterine fibroid.
d) FDG uptake in the uterus due to menstruation, uterine fibroid, physiologic bowel uptake.

24. b

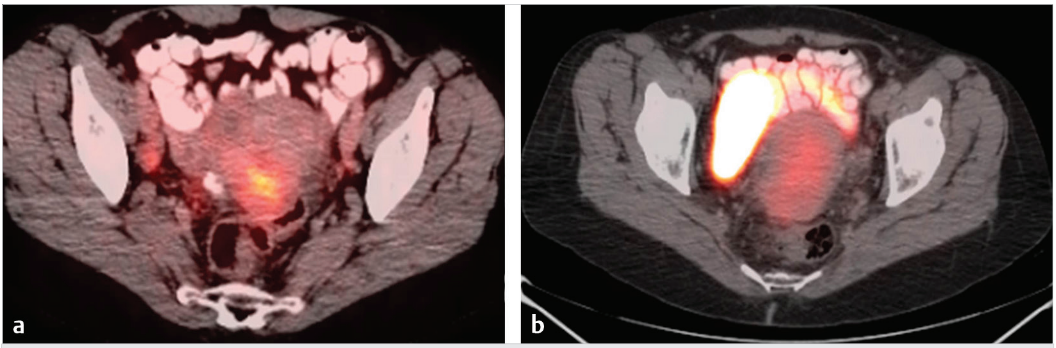

Fig. 18.8

25. You are shown a selected fused axial section from FDG-PET/CT study in a 48-year-old woman with history of leiomyosarcoma and total abdominal hysterectomy 10 months ago (▶Fig. 18.9).

Which one of the following is the most likely diagnosis?

a) Inflammatory granuloma
b) Lymph node
c) Tumor implant
d) None of the above

25. c

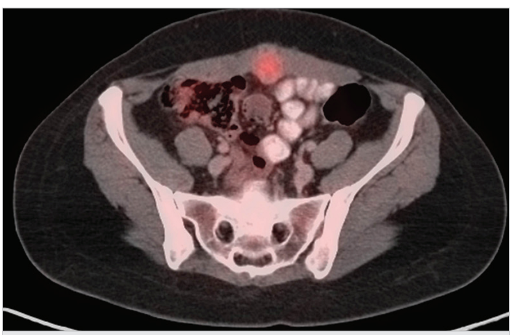

Fig. 18.9

26. A 59-year-old woman with history of ovarian cancer, status post total abdominal hysterectomy, and bilateral salpingo-oophorectomy underwent FDG-PET/CT due to elevated tumor markers. Selected fused axial PET/CT and an MIP image from the study are shown (▶Fig. 18.10a, b). Which of the following is true regarding FDG-PET utilization in restaging of ovarian cancer? (Choose all that apply.)

a) FDG-PET is valuable in patient with rising CA-125 and negative conventional imaging.
b) FDG-PET is valuable to distinguish postsurgical change from recurrence.
c) FDG-PET is limited in detection of small disseminated lesions in the peritoneum.
d) FDG-PET is limited for differentiating peritoneal tumors from adjacent bowel activity.
e) All of the above.

26. e, all of the above

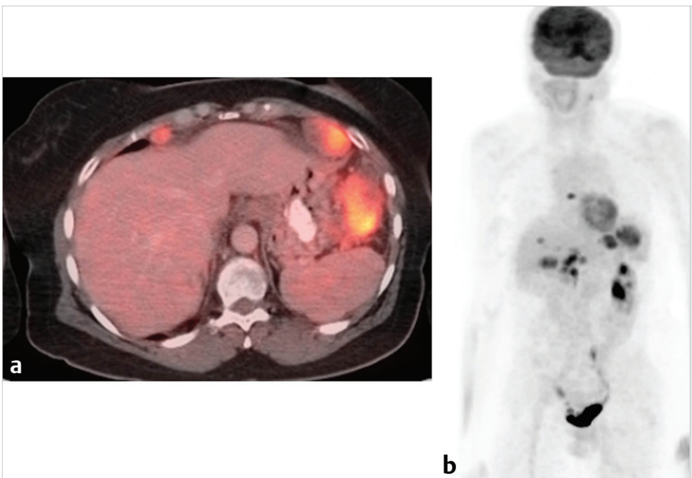

Fig. 18.10

27. An 82-year-old woman with RCC underwent FDG-PET/CT for initial staging. Axial fused PET/CT image is shown (▶Fig. 18.11).

Which of the following statements concerning RCC are true? (Choose all that apply.)

a) FDG-PET uptake by primary RCC is variable.
b) CT is the imaging modality of choice for diagnosis and staging of RCC.
c) Negative FDG-PET scan excludes RCC.
d) FDG-PET may be used to monitor therapy.
e) FDG-PET/CT has higher sensitivity and accuracy when compared with bone scan to detect RCC metastasis to the bone.

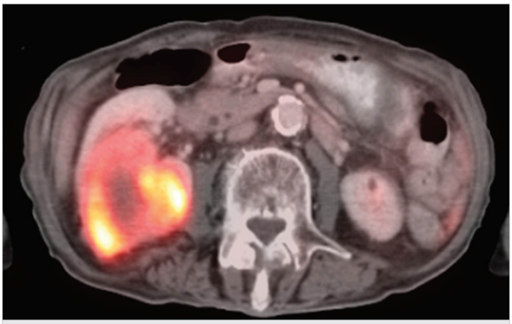

Fig. 18.11

27. a, b, d, and e

28. A 79-year-old man with prostate cancer underwent FDG-PET/CT. Axial fused PET/CT image is shown (▶Fig. 18.12).

Which of the following statements concerning prostate carcinoma are true? (Choose all that apply.)

a) Most primary prostate carcinomas demonstrate low uptake of FDG.
b) FDG-PET can reliably differentiate carcinoma from benign prostate hypertrophy.
c) FDG-PET is more sensitive than a bone scan in detecting sclerotic bone metastasis.
d) Focal intense FDG activity in the prostate should be correlated with serum PSA.
e) FDG-PET may be helpful for detection and localization of distant metastases in hormone-refractory prostate cancer.

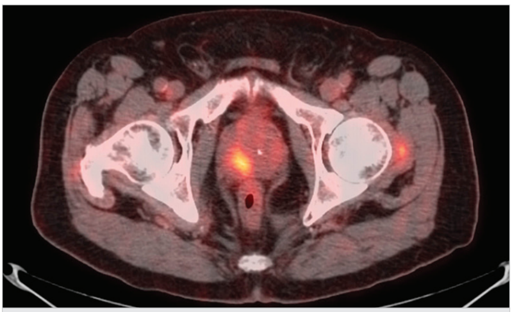

Fig. 18.12

28. a, d, and e

19 Lymphomas

Questions

1. True or false: Non-Hodgkin's lymphomas (NHLs) are a complex and heterogeneous set of many diseases.
2. True or false: The most common type of low-grade lymphoma is called B-cell small-cell lymphocytic.
3. True or false: NHLs are clinically divided into low-grade and high-grade, according to their natural history and survival.
4. True or false: Because low-grade NHLs are generally incurable, new treatments such as radioimmunotherapy (RIT) are being sought.
5. True or false: In a stage III NHL, there is involvement of lymph node regions on both sides of the diaphragm.
6. True or false: Diagnostic computed tomography (CT) provides incremental value as compared with positron emission tomography/computed tomography (PET/CT) in the evaluation of lymphoma.
7. True or false: The accurate staging of Hodgkin's lymphoma is important for guiding the choice of therapy and provides critical prognostic information.
8. Follicular lymphomas constitute what percentage of all NHLs?
   a) 5 to 10%
   b) 10 to 20%
   c) 20 to 25%
   d) 30 to 40%
   e) 50%
9. Which of the following forms of nuclear imaging is (are) useful or experimental in lymphoma?
   a) ^{18}F-FDG
   b) ^{67}Ga (limited by spatial resolution, intestinal activity, low-grade tumors, and delayed scan time periods)
   c) ^{68}Ga, ^{66}Ga
   d) ^{18}F-FLT
   e) All of the above

Answers

1. True.
2. False.
3. True.
4. True.
5. True.
6. False.
7. True.
8. c, 20 to 25%
9. e, all of the above

10. True or false: PET is as accurate as CT for staging patients with Hodgkin's disease (HD).

11. When compared with CT, fluorodeoxyglucose (FDG) PET upstages patients with HD in what percentage of patients?

a) 5 to 10%
b) 10 to 20%
c) 20 to 25%
d) 30 to 40%
e) 50%

12. FDG-PET changes the management of patients with HD after conventional workup in what percentage of cases?

a) 5 to 10%
b) 10 to 20%
c) 20 to 25%
d) 30 to 40%
e) 50%

13. Which lymphomas have intense FDG uptake?

14. Which lymphomas have low or moderate FDG uptake?

15. True or false: FDG-PET has excellent sensitivity (greater than 90%) for the diagnosis and staging of patients with B-cell small-cell lymphocytic lymphoma.

16. True or false: FDG-PET has excellent sensitivity for the diagnosis and staging of patients with follicular lymphomas.

17. True or false: FDG-PET has moderate sensitivity (70–80%) for the diagnosis and staging of patients with marginal zone lymphoma.

18. True or false: The accuracy of PET in low-grade lymphomas is equal to that in high-grade lymphomas, except in B-cell small-cell lymphocytic lymphoma.

19. True or false: Focal PET uptake is highly sensitive and might obviate the need for bone marrow biopsy in HD and aggressive NHL.

20. True or false: When receiver operating characteristic (ROC) curves are used for comparison of diagnostic accuracy, PET is found to be more accurate than CT for patients with NHL.

10. False.

11. b, 10 to 20%

12. b, 10 to 20%

13. Hodgkin, diffuse large B-cell, mantle cell, and follicular lymphomas.

14. Small lymphocytic, marginal zone B-cell, mucosa-associated lymphoid tissue (MALT), peripheral T-cell lymphomas.

15. False.

16. True.

17. True.

18. True.

19. True.

20. True.

21. True or false: Studies comparing FDG uptake with tumor grade have shown that aggressive lymphomas tend to have a higher FDG avidity than indolent histologies.

21. True.

22. True or false: In patients with low-grade lymphomas who undergo large-cell transformation followed up with PET, all FDG-avid foci demonstrate a significant rise of standard uptake value (SUV) as compared with a baseline scan.

22. False.

23. True or false: A predominant number of large cells on histological examination from a lesion previously labeled as indolent indicate conversion to a high-grade disease.

23. True.

24. True or false: A significant impact of PET on the management of children with lymphoma has not been demonstrated.

24. False.

25. True or false: A partial volume effect can be seen when there is radiotracer uptake in structures less than twice the spatial resolution of the instrument.

25. True.

26. True or false: The best time for end-of-treatment evaluation of patients with lymphoma is unknown, but most investigators recommend waiting at least 1 week after the last day of chemotherapy.

26. False.

27. True or false: Whenever possible, the early assessment of response to treatment is performed on the last day before a new cycle of chemotherapy.

27. True.

28. True or false: Early response evaluation after one or a few cycles or at mid-treatment (iPET) can predict progression-free survival and overall survival in lymphoma patients, but whether PET response-adapted therapy results in improved outcomes remains uncertain.

28. True.

29. What are the recommendations of the imaging subcommittee of international harmonization project regarding PET evaluation after therapy?

a) At least 3 weeks, and preferably at 6 to 8 weeks, after chemotherapy or chemoimmunotherapy
b) 8 to 12 weeks after radiation or chemoradiotherapy
c) Posttreatment routine surveillance
d) 2 weeks after granulocyte colony stimulating factor (G-CSF) therapy

29. a, b, and d

30. What are the guidelines of the international harmonization project regarding PET evaluation and interpretation of lymphoma response?

a) Visual assessment is adequate for positive or negative response after completion of therapy.
b) To compare the response with mediastinum blood pool activity if the residual mass or lymph node is greater than 2 cm, and to background if it is less than or equal to1 cm.
c) Specific criteria were described for PET positivity in the liver, spleen, lung, and bone marrow.
d) All of the above.

30. d, all of the above

31. What is the preferred reporting method for evaluation of PET uptake in lymphoma?

31. The Deauville criteria are the preferred reporting method for interim as well as end of the treatment PET evaluation in lymphoma and utilize a 5-PS score

32. What score constitutes complete metabolic response as per the Deauville criteria?

32. Scores 1 and 2 represent complete metabolic response. (Score 3 also represents complete metabolic response in nontrial conventional treatments)

33. True or false: Categorization of Deauville scores 4 and 5 (partial, residual, progression, etc.) depends on the change from baseline and timing of the PET scan.

33. True.

34. True or false: Quantification methods for PET evaluation of lymphoma (change in SUV max, SUV peak, etc., in combination with other parameters) are investigational and require standardization of dosing and imaging protocols.

34. True.

35. True or false: The Lugano classification represents consensus guidelines and incorporate both CT and PET scan for staging and management of lymphoma.

35. True.

36. True or false: Despite a high uptake of FDG in the normal brain, very intense uptake in most primary cerebral lymphomas renders PET a useful technique.

36. True.

37. Which is the diagnostic modality of choice for evaluation of central nervous system (CNS) involvement in lymphoma?

37. MRI.

38. True or false: At the completion of treatment, conventional imaging (CT and/or magnetic resonance imaging [MRI]) will reveal residual masses in approximately 20% of patients with lymphoma.

38. False.

39. Residual masses at the completion of treatment are reported to be positive for lymphoma on biopsy in what percentage of cases?

a) 5 to 15%
b) 15 to 20%
c) 20 to 30%
d) 30 to 40%
e) 40 to 50%

39. b, 15 to 20%

40. True or false: The presence of residual disease on a PET scan after completion of chemotherapy and before stem-cell transplantation indicates a high likelihood of poor response and recurrence after transplantation.

40. True.

41. True or false: Because most of the curable NHLs belong to the low-grade group, RIT has been proposed as an alternative treatment for patients with high-grade NHL.

41. False.

42. True or false: Currently, there are two radiopharmaceuticals approved in the United States for the treatment of NHL: ^{90}Y–ibritumomab tiuxetan (Zevalin) and ^{131}I-tositumomab (Bexxar).

42. True.

43. True or false: The antigen targeted by commercially available radiolabeled drugs for treatment of NHL is the CD18 antigen.

43. False.

44. True or false: RIT of NHL is based on the therapeutic success of immunotherapy with rituximab.

44. True.

45. True or false: The antibodies used in therapy have a selective affinity for the malignant lymphocytes.

45. False.

46. True or false: Pretreatment with the cold antibody is necessary because of the high density of the antigen on normal lymphocytes.

46. True.

47. The advantages of using a ^{90}Y-labeled antibody over a ^{131}I-labeled one include which of the following? (Choose as many as apply.)

a) ^{90}Y has higher energy beta (β) rays than ^{131}I.
b) ^{90}Y is a pure β-emitter and requires fewer radiation safety precautions.
c) Radiometals such as ^{90}Y are retained in tissues once the antibody is catabolized.
d) Because there are minimal individual variations in excretion patterns, dosimetry is not required.
e) None of the above.

47. a, b, and d

48. The advantages of ^{131}I- over ^{90}Y-labeled antibodies include which of the following? (Choose all that apply.)

a) Because ^{131}I is a beta (β) and gamma (γ) emitter, it can be used for both imaging and therapy.
b) Radiation safety precautions are minimal.
c) The performance of dosimetry measurements allows for the tailoring of the treatment dose to each patient.
d) None of the above.

48. a and c

49. True or false: Both RIT drugs approved in the United States bind only with the normal and malignant B-lymphocytes and not to the stem cells or to the plasma cells.

49. True.

50. True or false: RIT drugs may be associated with mucositis, hair loss, and persistent nausea and vomiting.

50. False.

51. True or false: The predominant toxicity of RIT drugs is hematological and includes thrombocytopenia, neutropenia, and anemia.

51. True.

52. True or false: Hematological toxicity occurs within 1 week of treatment with RIT drugs and lasts only a few days.

52. False.

53. True or false: The commercially available RIT drugs are indicated for the treatment of patients with relapsed or refractory low-grade, follicular, or transformed B-lymphocyte NHL, including patients with rituximab-refractory follicular NHL.

53. True.

54. True or false: There are no significant immunological reactions with the two approved RIT drugs, because the antibody moiety is human or chimeric.

54. False.

55. True or false: A fixed-dose approach, based on body weight and bone marrow status, is used for ^{90}Y-ibritumomab, whereas the dose of ^{131}I-tositumomab varies depending on body pharmacokinetics and the weight the individual patient.

55. True.

56. A 77-year-old man with lymphocyte predominant HD presents with new FDG-avid enlarged left supraclavicular lymph node, preaortic and para-aortic FDG-avid lymphadenopathy suggestive of FDG-avid progressive/worsening lymphoma (▶Fig. 19.1a, b). How would you categorize these findings based on the Deauville criteria and Lugano classification?

56. Uptake markedly higher than liver and new lesions consistent with Deauville 5-PS score of 5 and a Lugano classification of progressive disease.

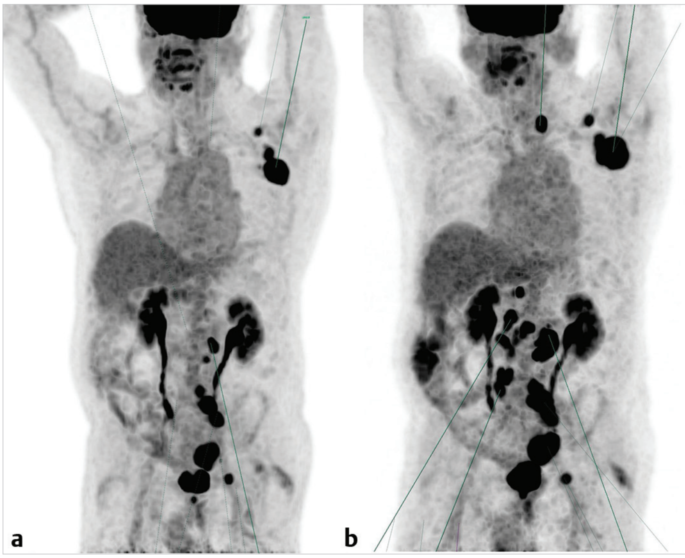

Fig. 19.1

57. A 53-year-old man with angioimmunoblastic T-cell lymphoma referred for restaging demonstrating Deauville score of 4. Spleen demonstrates intense uptake and measures 16 cm in length (▶Fig. 19.2). What findings are suspicious for involvement of spleen?

Fig. 19.2

57. Findings of splenomegaly (>13 cm in vertical dimension), focal or multifocal uptake, diffuse uptake greater than liver, and splenic hilar adenopathy are suggestive of splenic involvement. Spleen uptake can be reactive secondary to treatment, and is usually diffuse.

58. True or false: Pre- and posttreatment images of a 19-year-old woman with Hodgkin's lymphoma demonstrating a Deauville score of 1 and Lugano classification of complete response. PET/CT scan is preferred compared to CT alone, and can be performed for baseline staging, interim evaluation (iPET), and posttreatment response assessment (▶Fig. 19.3a, b).

58. True.

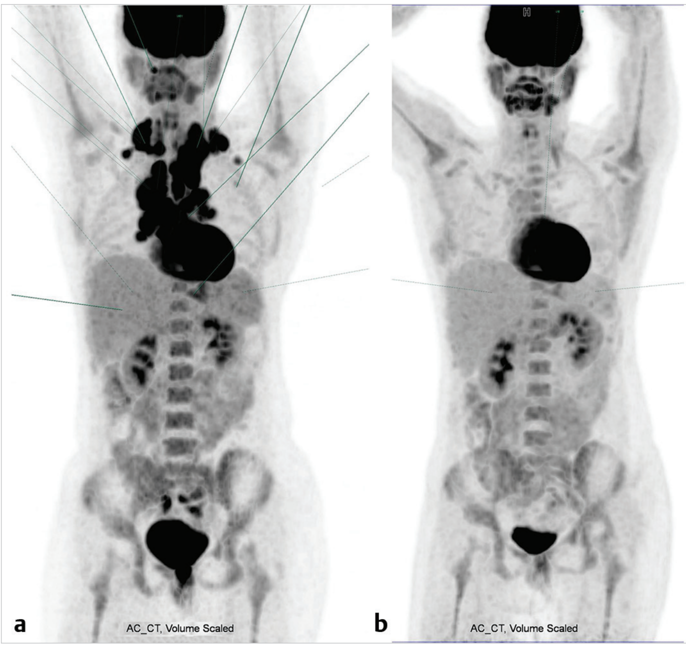

Fig. 19.3

59. Two different patients demonstrating cutaneous lesions with FDG uptake consistent with biopsy-proven history of T cell cutaneous lymphoma or mycosis fungoides (▶Fig. 19.4a, b).

Which of the following are true?

a) Cutaneous lymphomas usually have lower uptake.
b) Higher uptake indicates more aggressive type or transformation and poor prognosis.
c) PET/CT is more sensitive compared to CT alone.
d) All of the above.

59. d, all of the above

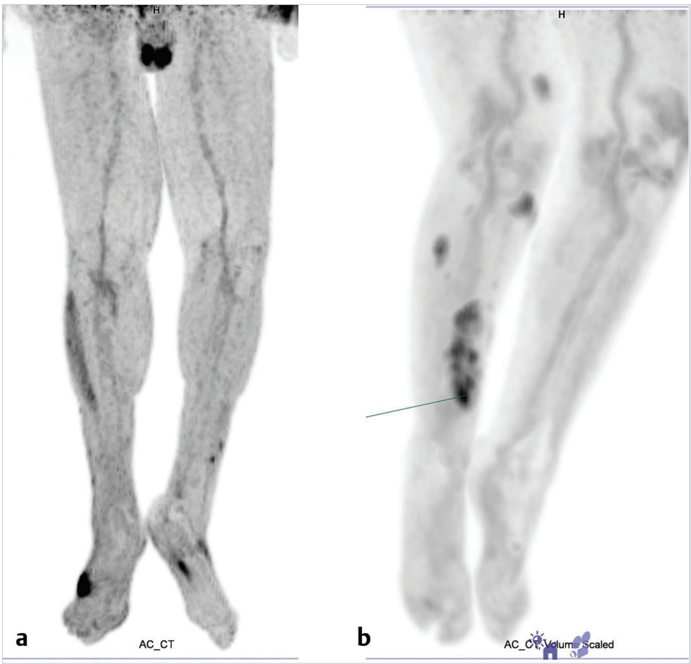

Fig. 19.4

60. Intense FDG uptake in the left frontal mass consistent with known diffuse B-cell lymphoma (▶Fig. 19.5).

Which of the following are true?

a) MRI is the modality of choice for evaluation of CNS involvement
b) PET is limited for evaluation of CNS involvement due to high background activity as well inability to identify leptomeningeal disease but can be helpful if focal intense uptake is seen
c) Primary CNS lymphoma is rare, and CNS involvement secondary to systemic lymphoma is more common.
d) All of the above.

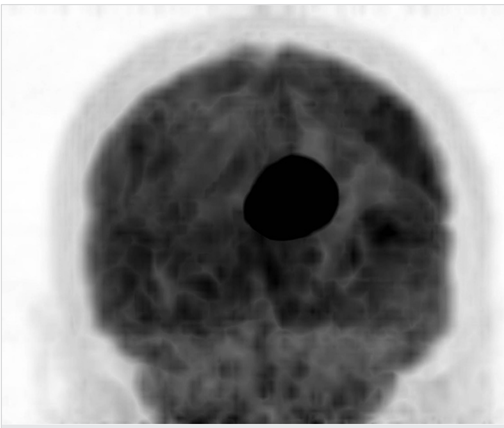

Fig. 19.5

60. d, all of the above

61. True or false: Diffuse marrow uptake is identified in this patient without demonstrable osseous disease due to recent administration of GCSF. However, focal abnormal sternal uptake was identified in additional to right neck disease. A minimum of 2 weeks after GCSF treatment, 3 weeks but preferably 6 to 8 weeks after chemotherapy, and 3 months after radiation therapy are recommended to assess posttreatment response in lymphoma (▶Fig. 19.6).

61. True.

Fig. 19.6

62. True or false: Interim PET/CT is superior to CT alone for evaluation of early response and is a better predictor of response and outcomes; however, changing treatment based on PET findings alone is not supported unless there is definitive evidence of progression (▶Fig. 19.7a, b).

62. True.

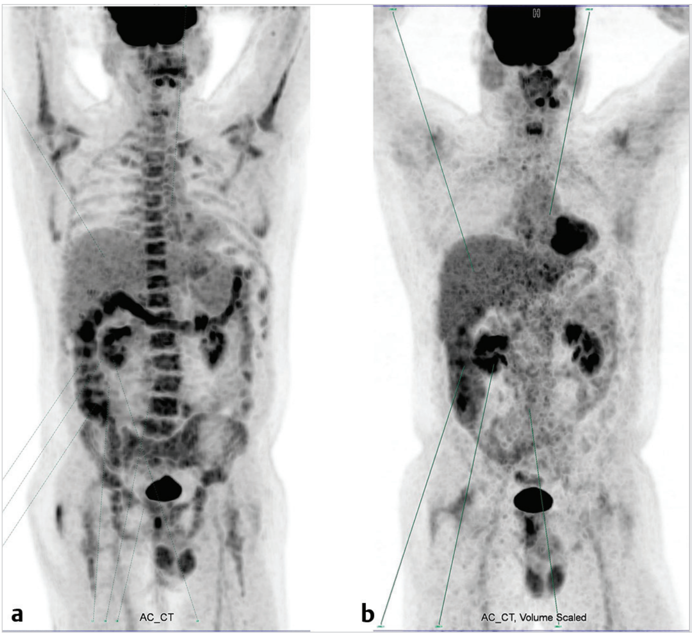

Fig. 19.7

63. No evidence of FDG-avid disease on PET scan during initial staging workup in a lymphoma patient (▶Fig. 19.8). What types of lymphoma are known to be less FDG-avid?

Fig. 19.8

63. MALT, marginal zone, small lymphocytic, and peripheral T-cell lymphomas.

20 Head and Neck Cancer

Questions

1. True or false: The correct staging of the cervical lymph nodes is critical to determine the necessary extent of surgery (type of neck dissection) and for precise delineation of the radiotherapy field in patients with head and neck cancer.
2. True or false: Fluorodeoxyglucose positron emission tomography (FDG-PET) has a higher sensitivity in the detection of nodal metastases in the initial staging of head and neck cancers compared to conventional imaging.
3. True or false: In patients with an N0 stage of the disease (no evidence of metastatic disease to the lymph nodes by clinical examination or conventional imaging), PET is a reliable modality to exclude malignant involvement of cervical lymph nodes.
4. True or false: Approximately 20 to 30% of patients with N0 disease are found to have metastatic disease at surgery, and 40% of these cervical node metastases are less than 1 cm in size.
5. True or false: Positron emission tomography/computed tomography (PET/CT) has not been shown to be more accurate than PET alone for staging patients with head and neck cancer.
6. True or false: Sentinel node imaging and biopsy offer a great potential benefit for patients with N0 disease because the majority of these patients who undergo a neck dissection are unlikely to have a therapeutic effect from this procedure.
7. True or false: FDG-PET does not provide any advantage over conventional imaging in the detection of contralateral neck and distant metastatic disease in the chest and abdomen.

Answers

1. True.
2. True.
3. False.
4. True.
5. False.
6. True.
7. False.

8. True or false: Given the high specificity of PET, it may be advisable to refer N0 patients with a positive PET to surgeons for neck dissection, while those N0 patients with a negative PET could undergo sentinel node biopsy prior to surgery.

8. True.

9. True or false: PET/CT is routinely used in the radiotherapy planning of patients with head and neck cancers because its use in this setting has been validated in large populations.

9. False.

10. True or false: One of the major potential advantages of including PET/CT in radiotherapy planning would be protecting the parotid glands from unnecessary exposure.

10. True.

11. In patients with metastatic cervical carcinoma of unknown origin who have undergone a full negative workup including endoscopy, FDG-PET may reveal the primary in what percentage of cases?

a) 5 to 10%
b) 10 to 20%
c) 20 to 40%
d) 40 to 60%
e) 60 to 70%

11. c, 20 to 40%

12. True or false: PET is more accurate than conventional imaging for detection of residual and recurrent disease after radiation or chemoradiation.

12. True.

13. True or false: If PET is used for the evaluation of patients before salvage surgery, it is best to wait at least 3 months after completion of chemoradiation to improve its predictive value.

13. True.

14. The role of FDG-PET in head and neck malignancies includes:

a) providing accurate staging of locoregional disease at diagnosis and recurrence, with impact on prognosis and management decisions
b) identifying the primary site in 20 to 50% of the cases with an unknown primary (5% of cases are of unknown primary)
c) accurately detecting distant metastasis, although distant metastases at diagnosis are uncommon in head and neck malignancies
d) all of the above
e) none of the above

14. d, all of the above

15. What is the current status of Medicare and Medicaid coverage for head and neck malignancies?

a) Both initial and subsequent treatment strategies are covered indications.
b) Initial treatment strategy is covered, whereas subsequent treatment strategy is covered only through National Oncologic PET Registry (NOPR).
c) Both initial and subsequent treatment strategy evaluations are CED (coverage with evidence development) and covered through NOPR only.
d) Not covered.

16. True or false: CT is the preferred imaging modality for small lung metastasis.

17. This finding is seen in a pediatric patient who has a history of lymphoma status post treatment (▶Fig. 20.1). This is most compatible with:

a) new head and neck malignancy
b) lymphoma recurrence in the tonsils
c) physiologic uptake in Waldeyer's ring
d) none of the above

15. a, both initial and subsequent treatment strategies are covered indications

16. True.

17. c, physiologic uptake in Waldeyer's ring

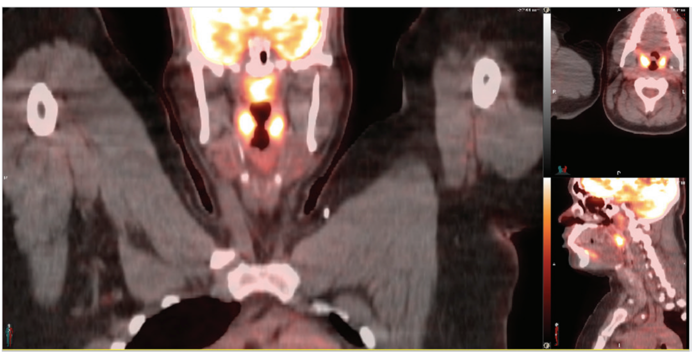

Fig. 20.1

18. What is this finding in a patient who has had chemotherapy for Hodgkin's lymphoma (▶Fig. 20.2)?

a) Disease recurrence in the mediastinum
b) Thymic hyperplasia
c) Disease recurrence in the lung
d) None of the above

18. b, thymic hyperplasia

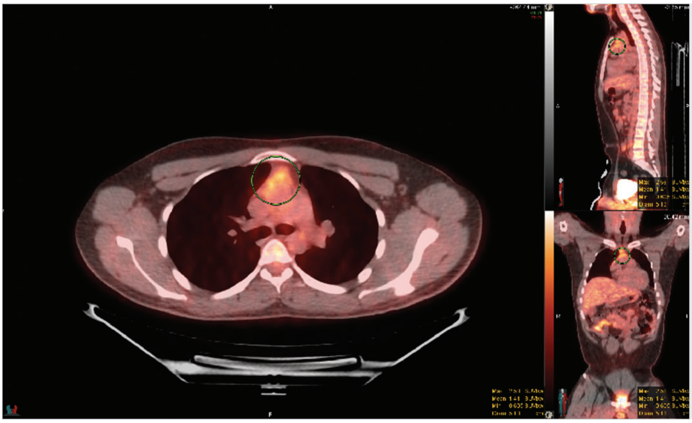

Fig. 20.2

19. Patient with left buccal cancer, status post radical left neck dissection (▶Fig. 20.3).

What is the most likely cause of uptake in the right tonsil?

a) Disease recurrence
b) Physiologic uptake in the right tonsil that appears asymmetric due to surgery and treatment on the left
c) Infection
d) Warthin's tumor

19. b, physiologic uptake in the right tonsil that appears asymmetric due to surgery and treatment on the left

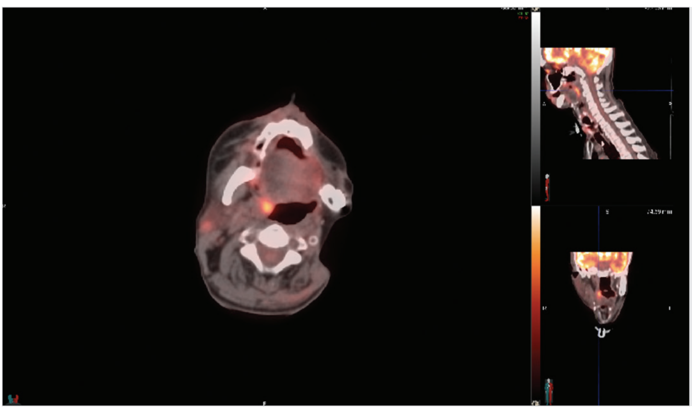

Fig. 20.3

20. Patient with laryngeal cancer status post surgery and radiation/chemotherapy (▶Fig. 20.4).

What is the likely cause of the finding seen here?

a) Disease recurrence
b) Coughing
c) Inflammation around tracheostomy
d) Brown fat

20. c, inflammation around tracheostomy

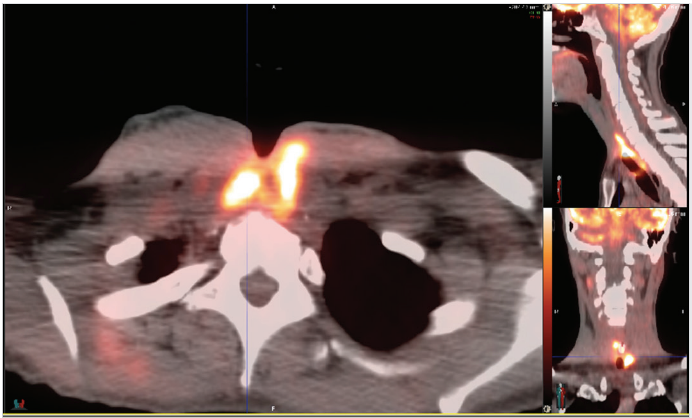

Fig. 20.4

21. What is the likely cause of this finding in a patient with treated breast cancer (▶Fig. 20.5)?

a) Metastatic disease from breast cancer
b) Reactive lymph node
c) Metastasis from a separate primary malignancy
d) None of the above

21. b, reactive lymph node

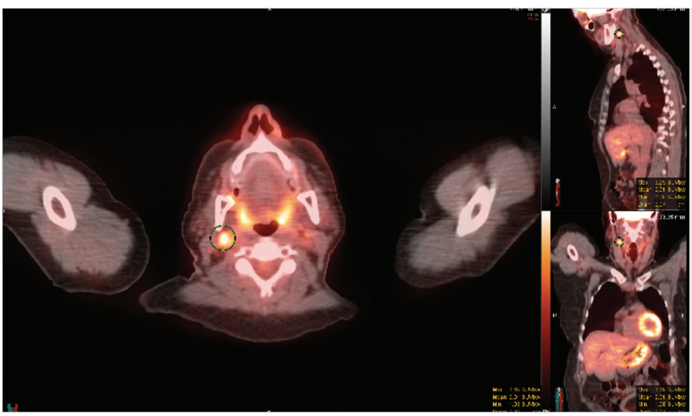

Fig. 20.5

22. What is the most likely cause/pathology of this finding (▶Fig. 20.6)?

a) Squamous cell cancer of tonsil
b) Lymphoma involving tonsil
c) Physiologic uptake
d) a or b

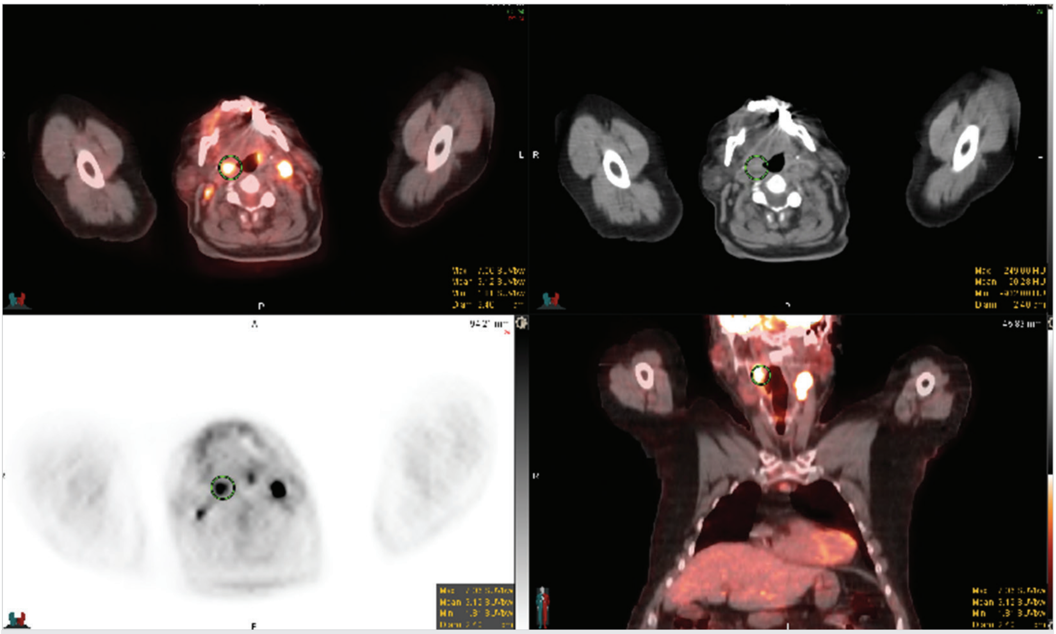

Fig. 20.6

23. What does the finding likely represent in an elderly man with lung cancer (▶Fig. 20.7)?

a) Bilateral parotid malignancy
b) Physiologic uptake
c) Benign tumor such as pleomorphic adenoma or Warthin's tumor
d) Metastasis to parotids

22. d

23. c, benign tumor pleomorphic adenoma or Warthin's tumor

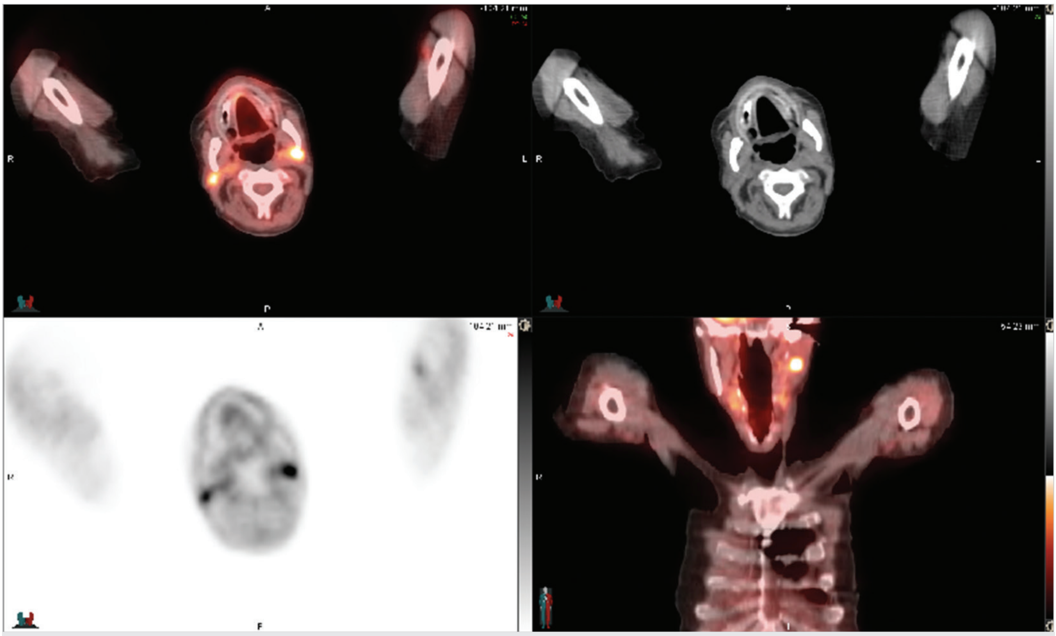

Fig. 20.7

24. FDG uptake (▶ Fig. 20.8) in the thyroid is likely due to:

a) thyroid cancer
b) thyroiditis
c) Synthroid use
d) either B or C

24. d

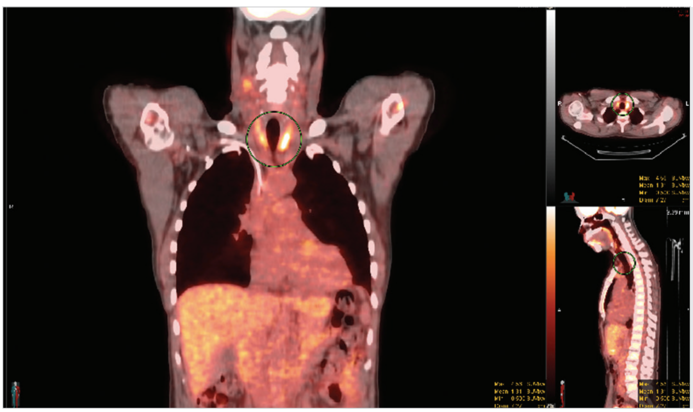

Fig. 20.8

25. What is the likelihood of malignancy in this incidental finding (▶Fig. 20.9)?

a) 40%
b) 10%
c) 90%
d) This is a completely benign finding.

25. a, 40%

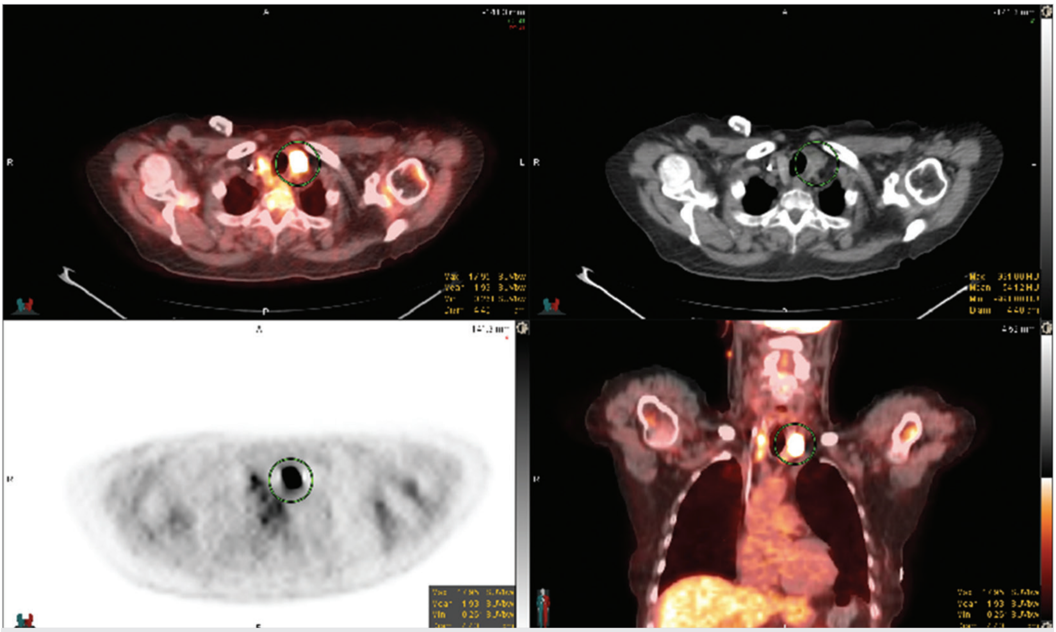

Fig. 20.9

26. What is the cause of the finding seen here in a pediatric patient status post lymphoma treatment (▶Fig. 20.10)?

a) Lymphoma recurrence
b) Physiologic brown fat uptake
c) Muscle uptake from inadequate fasting
d) Head and neck malignancy

26. b, physiologic brown fat uptake

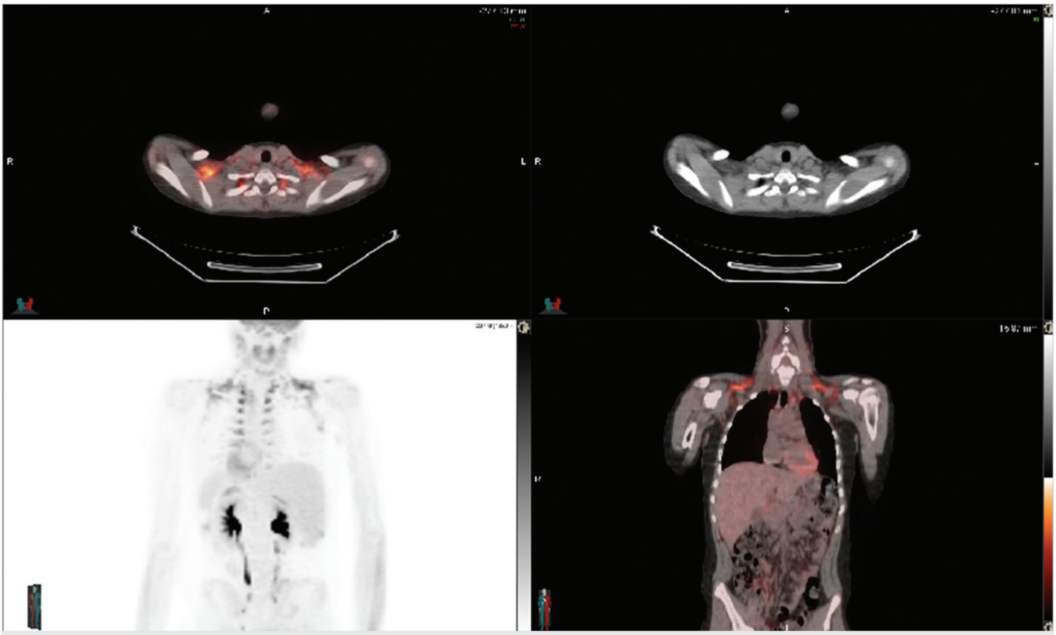

Fig. 20.10

21 Thyroid Cancer

Questions

1. True or false: Because well-differentiated thyroid cancer (WDTC) has a favorable natural history, studies using large numbers of patients are needed to demonstrate any therapeutic effect for radioiodine ablation (RAI).
2. True or false: The image quality and diagnostic accuracy of ^{131}I whole-body scans (WBSs) obtained after thyroid-stimulating hormone (recombinant human [rh] TSH) is clinically acceptable compared to those obtained after thyroid hormone withdrawal (THW).
3. True or false: THW or Thyrogen stimulation prior to ^{18}F-fluorodeoxyglucose (^{18}F-FDG) scan in evaluation of residual or recurrent disease is useful.
4. What is the current status of Medicare and Medicaid coverage for ^{18}F-FDG positron emission tomography (PET) in thyroid cancer?
   a) Covered for initial treatment strategy
   b) Covered for subsequent treatment strategy of follicular thyroid cancer
   c) Covered for subsequent treatment strategy of thyroid cancers other than follicular type
   d) Covered for evaluation of cases with elevated serum thyroglobulin (Tg) with a negative whole-body ^{131}I
   e) All of the above
5. True or false: Increased FDG uptake is seen in anaplastic, medullary, and hurtle cell thyroid carcinomas.
6. What are the FDA-approved indications for the use of rhTSH?

Answers

1. True.
2. True.
3. True.
4. d, Covered for evaluation of cases with elevated serum thyroglobulin (Tg) with a negative whole-body ^{131}I
5. True.
6. The use of rhTSH is approved for serum thyroglobulin (Tg) testing with or without radioiodine imaging in the follow-up of patients with WDTC, and for RAI of thyroid tissue remnants in patients who have undergone a near-total or total thyroidectomy for WDTC and who do not have evidence of metastatic thyroid cancer.

7. True or false: Tg is secreted by both normal and neoplastic thyroid cells.	**7.** True.
8. True or false: A limitation in interpreting Tg levels is the potential for interference by anti-Tg autoantibodies.	**8.** True.
9. True or false: Anti-Tg antibodies interfere with detection of metastatic foci on RAI scans.	**9.** False.
10. True or false: In general, the sensitivity rate for the detection of WDTC by measurement of Tg after THW is 85 to 95%, but it may be as low as 50% during hormonal therapy.	**10.** True.
11. True or false: There is evidence that using rhTSH is superior to using THW for stimulation of Tg to detect residual or metastatic WDTC.	**11.** False.
12. The cutoff level for Tg while on suppression above which a workup for residual or recurrent disease is required is: a) 1 mg/dL b) 2 mg/dL c) 2 mg/mL d) 5 mg/mL e) 10 mg/mL	**12.** c, 2 mg/mL
13. True or false: Current data suggest that ^{123}I scans using 2 to 5 mCi (74–185 MBq) imaged at 24 hours are superior to ^{131}I diagnostic and postablation scans.	**13.** False.
14. True or false: The term “thyroid stunning” is defined as the phenomenon in which a diagnostic ^{131}I dose decreases the uptake of a subsequent ablative dose of ^{131}I, thereby potentially lowering its therapeutic efficacy.	**14.** True.
15. True or false: There is abundant evidence that thyroid stunning has a definite effect on treatment outcomes when ^{131}I has been used for diagnostic scans.	**15.** False.
16. A patient with WDTC received RAI 1 year ago. The stimulated Tg is 7 mg/mL; the WBS is negative. The combination of these findings may be due to: a) inadequate TSH stimulation b) small tumor size c) recent iodine intravenous contrast d) a dedifferentiated tumor that has lost the ability to trap iodine but is maintaining the ability to synthesize Tg e) all of the above	**16.** e, all of the above

17. True or false: The next logical step in the treatment of a WBS-negative, Tg-positive patient would be to attempt localizing residual tissue with an ultrasound of the neck.

18. True or false: In patients who have a stimulated Tg of less than 10 mL and a negative WBS 1 year after RAI, FDG-PET has been shown to be very sensitive for the detection of residual or metastatic tissue.

19. True or false: An FDG-PET scan is generally well suited for the evaluation of WBS-negative, Tg-positive patients after initial ablation, because the FDG avidity of WDTC is often inversely proportional to its ^{131}I avidity.

20. True or false: Overall, FDG-PET scans have a high positive predictive value for residual disease when they are used in the follow-up treatment of all patients with WDTC who have received an initial RAI.

21. A patient with WDTC received RAI 1 year ago. The stimulated Tg is 103 mL; the WBS is negative. The TSH level is 45 IU/mL. The referring physician orders a PET scan. What is the likelihood of detecting disease with this scan?

a) Less than 10%
b) 20 to 30%
c) 40 to 50%
d) 50 to 60%
e) Greater than 70%

22. True or false: When a PET scan is performed on a patient with thyroid cancer, it is recommended that the patient have a high TSH.

23. True or false: At least 30% of patients with elevated Tg and negative WBS will have a positive postablation scan when empiric therapy with ^{131}I is used.

24. True or false: Patients with WDTC in the United States who are going to receive more than 30 mCi of ^{131}I for therapy or ablation require hospitalization.

25. True or false: Hürthle cell carcinomas have a higher percentage of non-iodine-avid tumors compared to other WDTC.

26. True or false: It is not advisable to evaluate medullary thyroid carcinoma patients with FDG-PET, because of the low sensitivity of this modality (< 50%) in this type of thyroid cancer.

17. True.

18. False.

19. True.

20. False.

21. e, greater than 70%

22. True.

23. True.

24. False.

25. True.

26. False.

27. Nuclear imaging of thyroid malignancies includes all of the following except:

a) thallium-201 or ^{99m}Tc-sestamibi WBSs
b) ^{18}F-FDG
c) experimental use of ^{124}I
d) ^{111}In pentetreotide or experimental use of ^{18}F-DOPA for medullary thyroid cancers
e) experimental use of ^{68}Ga-DOTA for medullary thyroid cancers
f) ^{67}Ga imaging
g) ^{123}I and ^{131}I scans

28. Which of the following regarding thyroid uptake on ^{18}F-FDG scan is not true?

a) Focal incidental uptake can represent malignancy in 25 to 50% of cases.
b) Diffuse mild bilateral uptake can be physiological.
c) Diffuse bilateral uptake can represent thyroiditis, Graves' disease, or hypothyroidism.
d) Further evaluation with thyroid function tests or imaging should be based on the clinical context.

27. f, ^{67}Ga imaging

28. b, diffuse mild bilateral uptake can be physiological

22 Neuro–Positron Emission Tomography

Questions

1. True or false: The overall accuracy of fluorodeoxyglucose positron emission tomography (FDG-PET) imaging in the detection of Alzheimer's disease (AD) is superior to that of single-photon emission computed tomography (SPECT)—with a sensitivity and specificity of 87 to 90% and 85 to 90%, respectively, as compared with 58 to 75% and 70 to 80%, respectively, for SPECT.
2. True or false: In general, the radiotracer distribution pattern in AD is similar for perfusion SPECT and FDG-PET. Radiotracer activity is decreased in the posterior parietal and temporal lobes.
3. True or false: False-positive PET studies for AD are almost always caused by another type of dementia present in the patients evaluated.
4. True or false: At present, though PET and SPECT are not part of the routine workup of AD, they can be useful for detecting AD early, differentiating AD from other forms of dementia, and monitoring treatment response.
5. True or false: Dementia with Lewy bodies (DLB) is a distinct clinical entity, definitely different from AD, and always manifested by widespread cerebral metabolic reductions most prominent in the temporal lobes.
6. True or false: In patients with vascular dementia (VD), lesions tend to be scattered throughout the brain (including the basal nuclei), are not symmetric, and seem to have well-defined boundaries associated with infarction.
7. True or false: Frontotemporal dementia (FTD) can be easily confused with AD on clinical grounds and is manifested by hypometabolism of the frontal and posterior temporal lobes.

Answers

1. True.
2. True.
3. True.
4. True.
5. False.
6. True.
7. False.

8. What is the typical pattern of FDG distribution in Alzheimer's dementia?

8. The typical pattern of FDG distribution is decreased glucose metabolism in the posterior temporal and parietal association cortices bilaterally, while in the primary sensorimotor cortex, visual cortex, and basal ganglia, glucose levels remain the same.

9. The earliest indication in Alzheimer's dementia is decreased activity in the __________ cortex, and in the advanced stage there is prominent __________ cortical involvement.

9. posterior cingulate; frontal

10. In DLB, there is usually involvement of the __________ in addition to the parietotemporal hypometabolism.

10. occipital or visual cortex

11. Identify the mechanism of action for the following neuro-PET tracers: PiB, ^{18}F-FDDNP, ^{11}C-nicotine, ^{15}O-H_2O, ^{11}C-raclopride, ^{11}C-N-methylpiperone, ^{18}F-DOPA.

11. PiB, fluorescent analog of thioflavin Y, binds beta (β) amyloid plaques in Alzheimer's dementia; ^{18}F-FDDNP binds to senile plaques and neurofibrillary tangles; ^{11}C-nicotine, cholinergic receptor loss in Alzheimer's dementia; ^{15}O-H_2O demonstrates reduced blood flow in areas of hypometabolism; ^{11}C-raclopride and ^{11}C-N-methylpiperone, dopamine receptor mapping; ^{18}F-DOPA, presynaptic dopaminergic function.

12. True or false: FDG-PET scanning is useful for differentiation of recurrent tumors from radiation therapy necrosis.

12. True.

13. Rank the following three examinations in terms of their sensitivity for detecting a seizure focus:

a) interictal FDG-PET
b) interictal perfusion SPECT
c) ictal perfusion SPECT

13. The choice is ictal PET, followed by ictal SPECT, interictal PET, and interictal SPECT in that order. The ictal PET findings might be noticed incidentally during electroencelphographic (EEG) monitoring of a PET study. The ictal studies demonstrate increased activity, whereas the interictal studies demonstrate decreased activity.

14. Decreased cerebellar activity contralateral to the location of the cortical neoplasm, stroke, or trauma as seen on a FDG-PET scan is known as __________.

14. crossed cerebellar diaschisis

15. When using ^{18}F (florbetapir) in patients suspected of AD, which of the following is false?

a) Patients can have abnormal cortical radiopharmaceutical uptake yet not have the diagnosis of AD.
b) Patients can have cortical radiopharmaceutical uptake and be affected with AD.
c) Patients can have no cortical radiopharmaceutical uptake and not have the diagnosis of AD.
d) Patients can have no cortical radiopharmaceutical uptake and yet have the diagnosis of AD.

15. d

16. The radiopharmaceutical ^{123}I (ioflupane), used for imaging of patients with suspected parkinsonian syndromes, has what mechanism of uptake?

16. Binds to presynaptic dopamine transporters.

17. Which of the following patterns supports the diagnosis of a parkinsonian syndrome? (Select one or more answers.)

a) Symmetric comma- or crescent-shaped focal regions of activity in the putamen and caudate bilaterally
b) Activity in the putamen of one hemisphere is absent or greatly reduced but caudate activity still preserved
c) Activity is absent in both putamen and is preserved in the caudate nuclei.
d) Activity is absent in both putamen and greatly reduced in one or both caudate nuclei.

17. b, c, or d

18. An 80-year-old patient presented with dementia.

Image (▶Fig. 22.1) suggests:
a) Alzheimer's dementia
b) Lewy body dementia
c) frontotemporal dementia
d) VD

18. d

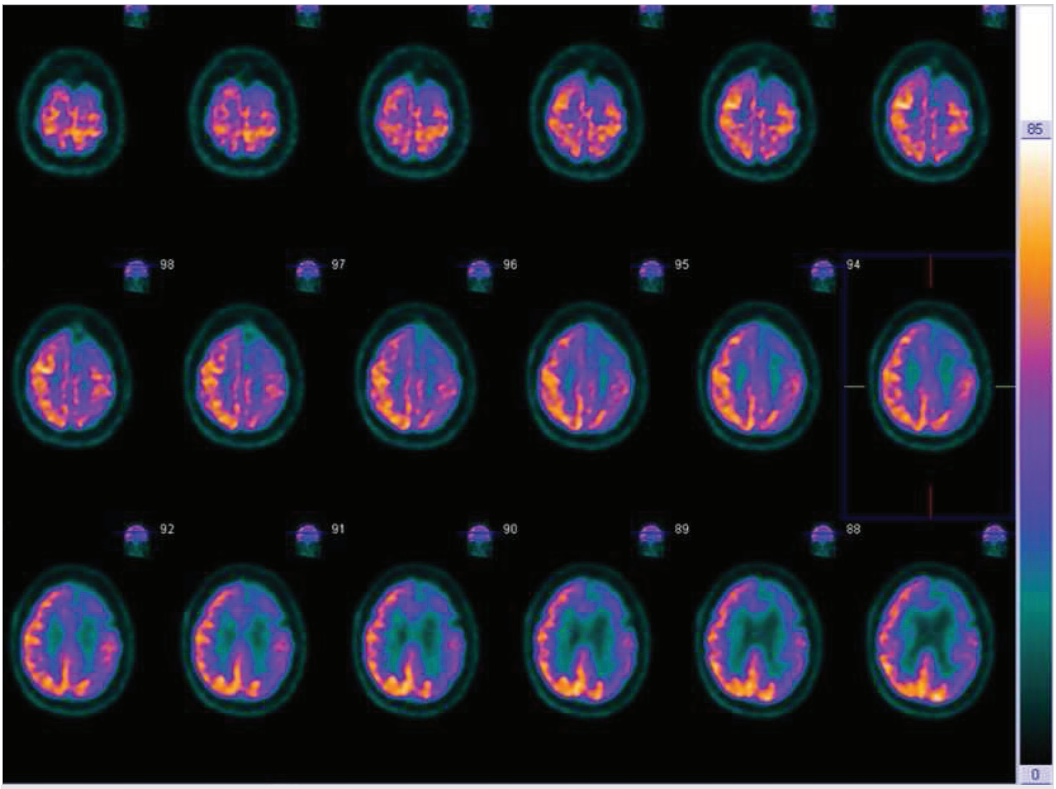

Fig. 22.1

19. Interictal ^{18}F-FDG-PET and ictal 99mTc-ECD and interictal ^{99m}Tc-ECD SPECT images (▶Fig. 22.2a–c) in a young female patient with history of epilepsy indicate abnormality within:

a) right temporal lobe
b) left temporal lobe
c) left parietal lobe
d) right frontal lobe

20. ^{18}F-FDG-PET/CT images of the brain in a patient with clinical diagnosis of dementia (▶Fig. 22.3a, b). Significant reduction in FDG uptake in the posterior cingulate cortex and bilateral parietotemporal cortices, and mildly reduced uptake in bilateral frontal cortices are seen.

This pattern of decreased uptake is most consistent with:

a) Parkinson's dementia
b) AD
c) FTD
d) Lewy body dementia

19. a

20. b

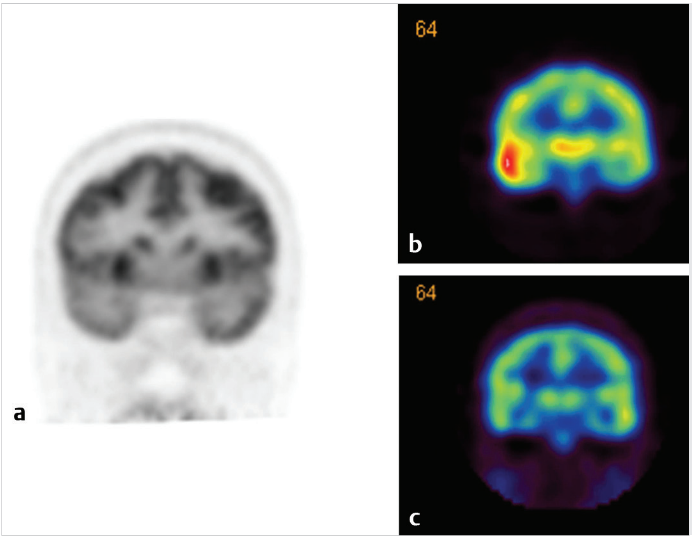

Fig. 22.2

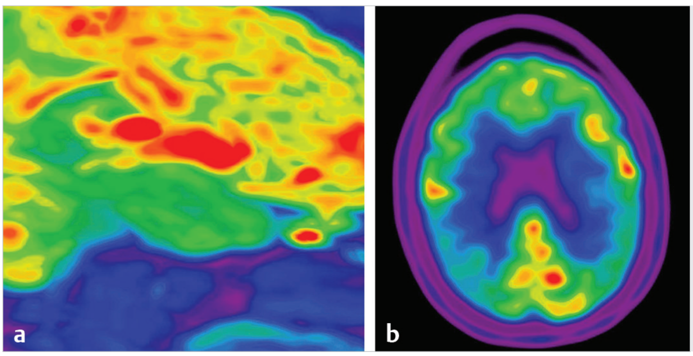

Fig. 22.3

21. Pattern of decreased ^{18}F-FDG uptake in Alzheimer's dementia (▶ Fig. 22.4):

a) Earliest change is usually noted in posterior cingulate gyrus.
b) Classic pattern involves posterior cingulate gyri, precuneus, and bilateral parietotemporal lobes.
c) Prefrontal and frontal lobe involvement is seen in advanced disease.
d) Anterior cingulate gyrus, sensorimotor cortex, and visual cortex, basal ganglia, thalamus, and cerebellum are spared.
e) All of the above.

21. e

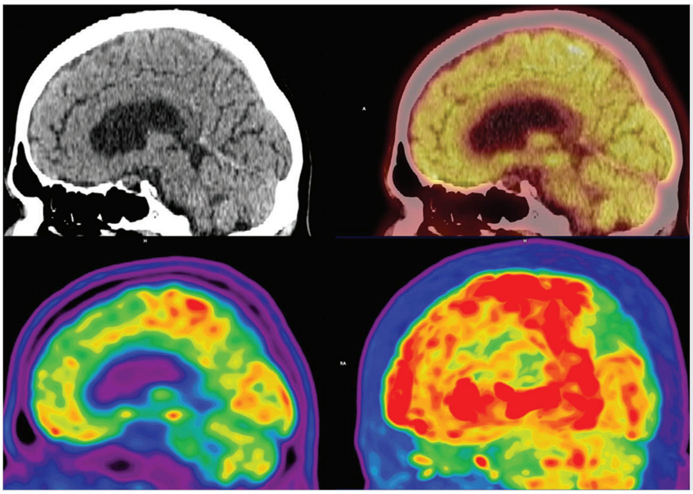

Fig. 22.4

22. Pattern of decreased FDG-PET uptake (see ▶Fig. 22.5a, b) is most consistent with:

a) AD
b) Parkinson's dementia
c) FTD
d) Lewy body dementia

22. c

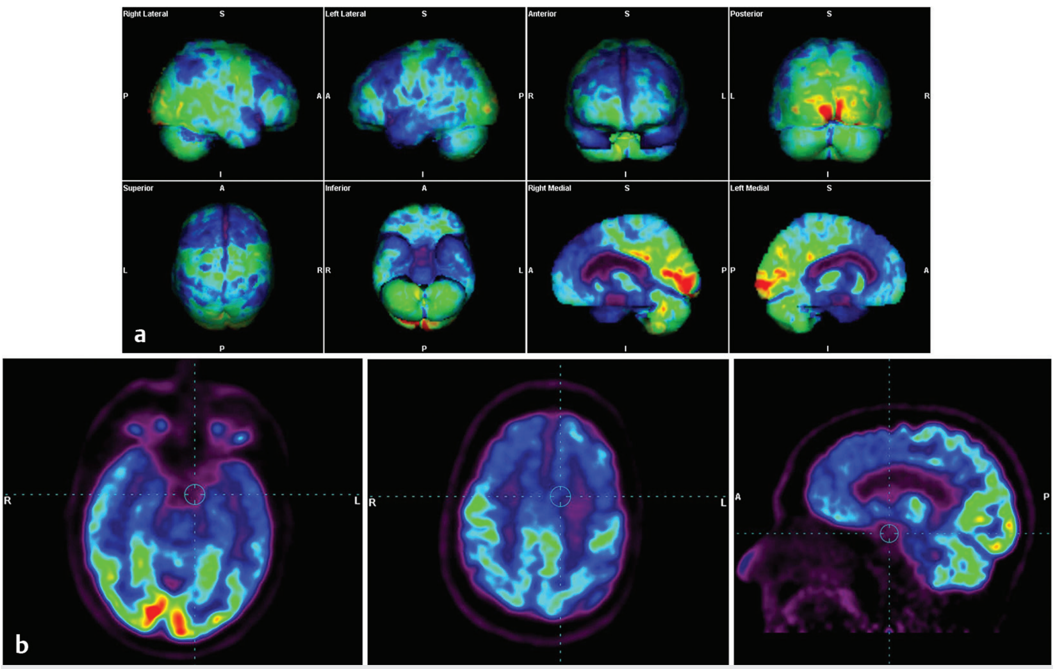

Fig. 22.5

23. ^{18}F scan (see ▶ Fig. 22.6a, b) indicates:

a) increased uptake in cortical gray matter; presence of amyloid plaque.
b) normal gray–white matter differentiation without increased cortical uptake; no evidence of amyloid plaque.
c) Alzheimer's dementia
d) nondiagnostic

23. b

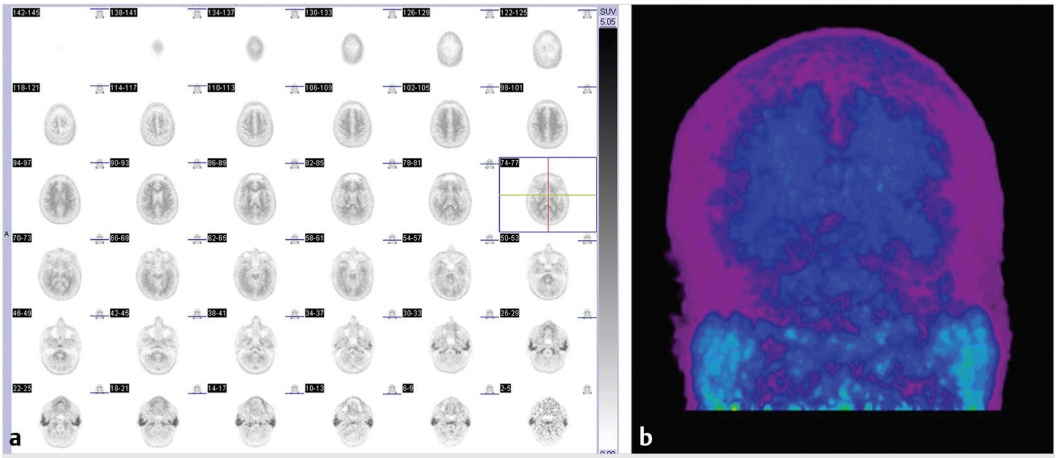

Fig. 22.6

24. ^{18}F scan (see ▶ Fig. 22.7a, b) in the above patient:

a) indicates increased uptake in cortical gray matter without gray–white differentiation; presence of moderate to frequent amyloid plaque.
b) indicates normal gray–white matter differentiation without increased cortical uptake; no evidence of amyloid plaque.
c) indicates Alzheimer's dementia.
d) supports diagnosis of Alzheimer's dementia in appropriate clinical setting.

24. a and d

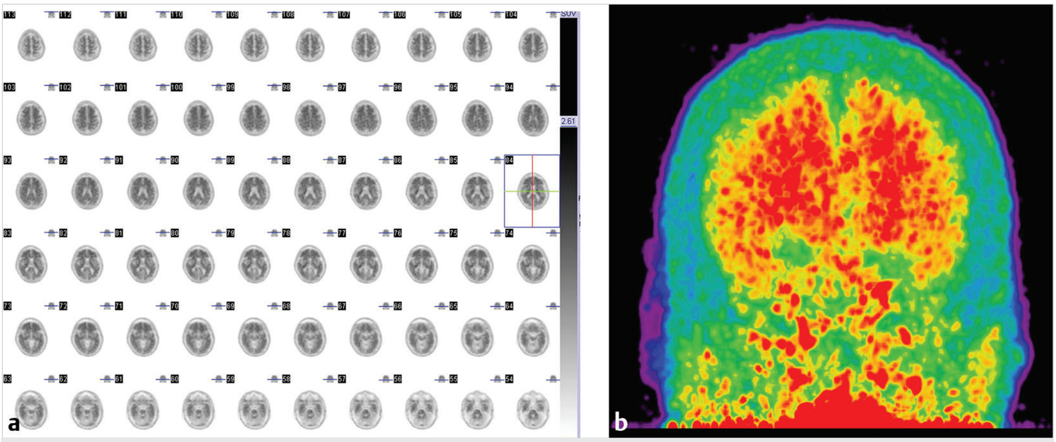

Fig. 22.7

25. Which of the following findings in the above patient (see ▶Fig. 22.8a, b) does not support the diagnosis of Alzheimer's dementia?

a) Decreased uptake in parietal cortex
b) Decreased uptake in visual cortex
c) Preserved posterior cingulate uptake
d) Relatively preserved frontotemporal uptake

25. b

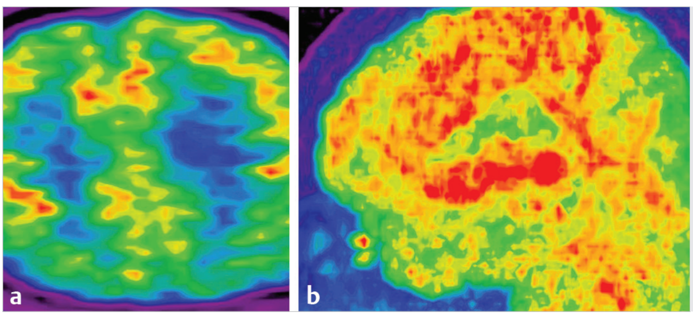

Fig. 22.8

26. ^{18}F-FDG images (see ▶Fig. 22.9a, b) in the above patient with chronic left frontal infarct demonstrate:

a) reperfusion injury
b) luxury phenomenon
c) crossed cerebellar diaschisis
d) perfusion metabolism mismatch
e) penumbral zone

26. c

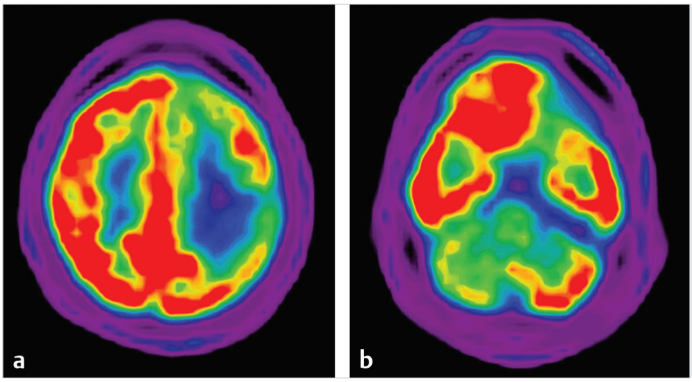

Fig. 22.9

27. MRI FLAIR (fluid-attenuated inversion recovery) images and ^{18}F-FDG-PET images (see ▸Fig. 22.10a, b) in this patient with epilepsy support a diagnosis of:

a) temporal lobe ganglioglioma
b) mesial temporal sclerosis
c) herpes simplex virus infection
d) lateral temporal epilepsy
e) arteriovenous malformation

27. b

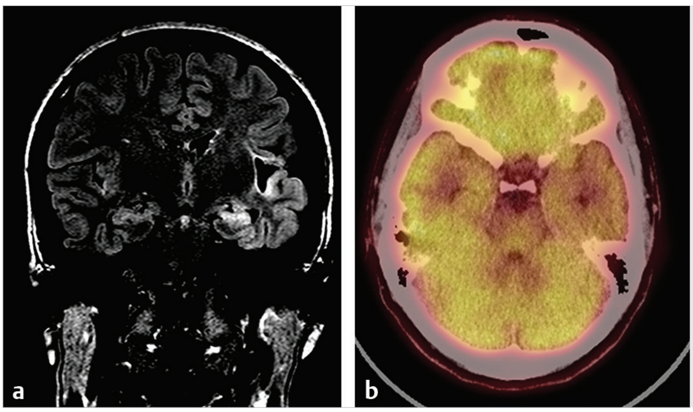

Fig. 22.10

23 Miscellaneous Positron Emission Tomography/ Computed Tomography

Questions

1. What indications are currently covered by Medicare and Medicaid for fluorodeoxyglucose (^{18}F-FDG) positron emission tomography (PET) scan in melanoma?

a) Initial treatment strategy
b) Initial staging of regional lymph nodes
c) Subsequent treatment strategy evaluation
d) All of the above

2. Which of the following statements regarding melanoma is (are) true?

a) PET is sensitive compared with other imaging modalities for evaluation of distant metastases that are widespread and in unusual locations.
b) Head-to-toe imaging is performed.
c) Computed tomography (CT) is best for detection of subcentimeter parenchymal lung lesions, and magnetic resonance imaging (MRI) is better for detection of brain metastasis.
d) PET does not replace sentinel lymph node scintigraphy evaluation.
e) All of the above.

3. Which of the following statements concerning primary cutaneous melanoma are true? (Choose as many as apply.)

a) The thicker the lesion, the worse the prognosis.
b) Ulceration carries a worse prognosis.
c) Macroscopic nodal metastases carry a worse prognosis than microscopic nodal metastases.
d) Lung metastasis carries a worse prognosis than other visceral metastases.
e) None of the above.

Answers

1. a and c

2. e, all of the above

3. a, b, and c

4. Which of the following statements concerning cutaneous melanoma are true? (Choose as many as apply.)

a) Sentinel node localization (SLN) and biopsy are important for initial staging depending on the thickness of the primary tumor.
b) FDG-PET is sensitive for detecting regional lymph node involvement and can substitute for SLN localization.
c) CT and MRI are the imaging procedure of choice for detecting small lung metastasis and brain metastasis, respectively.
d) The serum lactic dehydrogenase level is sensitive in predicting liver metastasis.
e) Overall, FDG-PET seems to be superior to other anatomic imaging for detecting regional and distant metastasis.

4. a, c, d, and e

5. What are the covered indications for PET in multiple myeloma?

5. Both initial and subsequent strategies are covered.

6. What is a DaTscan used to detect?

6. Parkinsonian syndromes.

7. What is the mechanism of action of the tracer used in a DaTscan?

7. ^{123}I (ioflupane) binds presynaptically to striatal dopamine transporters.

8. True or false: A normal DaTscan will show symmetric (comma) pattern of uptake in the caudate and putamen only.

8. True.

9. True or false: PET can detect the site of an occult primary in approximately 20 to 40% of cases.

9. True.

10. Explain the mechanism of the following carrier molecules utilized for PET imaging: ^{11}C-choline, ^{11}C-methionine, and thymidine.

10. ^{11}C-choline: a mechanism based on lipid and membrane synthesis; ^{11}C-methionine: amino acid/protein synthesis; and thymidine: DNA analysis.

11. Name tracers of perfusion.

11. ^{15}O-H_2O, ^{13}N-ammonia, and ^{82}Rb.

12. What are the PET tracers for hypoxia?

12. ^{18}F-misonidazole, ^{64}Cu-ATSM, ^{18}F-FAZA.

13. What is the apoptotic agent?

13. Radiolabeled annexin.

14. True or false: ^{18}F-galacto-RGD represents the biodistribution of avb3 integrin expression through binding to RGD-containing components on extracellular matrix that are upregulated in the tumor vasculature and are utilized in imaging of tumor angiogenesis.

14. True.

15. What is the mechanism of the bone PET agent ^{18}F-NaF?

15. Exchange diffusion. The fluoride ion is exchanged with the hydroxide ion of the hydroxyapatite structure of bone tissue to form ^{18}F-fluorapatite.

16. What is Amyvid?

16. ^{18}F (florbetapir), a brain imaging agent that binds to β amyloid plaques.

17. What is the normal radiotracer distribution in an Amyvid scan?

17. Activity more in the white matter compared to gray matter with a clear gray–white matter contrast.

18. True or false: An abnormal Amyvid scan is diagnostic for Alzheimer's disease.

18. False.

19. What is the mechanism of action of Ga-DOTATOC/DOTATATE?

19. Binding to somatostatin receptors 2 and 5.

20. What is the normal radiotracer distribution in a DOTATOC scan?

20. Thyroid, pituitary, pancreatic uncus and body, liver, spleen, kidneys, adrenals, and bowel.

21. What are the benefits of using Ga-DOTATOC over In-octreotide?

21. Less radiation, shorter injection to imaging time, better resolution, higher affinity for somatostatin receptors.

22. Which PET/CT radiotracer recently got approval for neuroendocrine tumors?

a) ^{18}F (florbetapir)
b) ^{68}Ga-DOTATATE
c) ^{68}Ga-PSMA
d) Annexin V

22. b

23. Which PET/CT radiotracer plays important role in the workup for prostate cancer?

a) ^{18}F-FDG
b) ^{68}Ga-DOTATATE
c) ^{68}Ga-PSMA
d) ^{18}F-fluciclovine

23. c and d

Part IV

Radionuclide Therapy

24 Radionuclide Therapy

Questions

1. Which one of the following is not a pure beta (β) emitter?
   a) Yttrium-90
   b) Strontium-89
   c) Phosphorus-32
   d) Iodine-131
2. What is the predominant purpose of pretreatment with a nonradioactive antibody during dosimetry and therapy?
3. What organ determines the dosage (or administered activity) limit for most radionuclide therapies?
4. __________ is the dose-limiting organ for ^{177}Lu-DOTATATE.
5. Which portion of the antibody is responsible for cytotoxicity and human anti-mouse antibody (HAMA)?
6. Which of the following are true regarding HAMA?
   a) It occurs in about one-third of patients treated with murine antibodies.
   b) It may produce falsely elevated tumor markers.
   c) Its titers spontaneously resolve in the majority of cases.
   d) It alters biodistribution for future radionuclide therapies.
   e) All of the above.
7. __________ antigen, which is expressed in 90% of mature B-cells and not in progenitor stem cells, and which is not shed or internalized, is utilized as the target antigen for lymphoma therapy.
8. A therapeutic advantage of radioactive-labeled antibody versus a nonradiolabeled antibody in the treatment of lymphoma is due to beta (β) radiation resulting in __________ effect.

Answers

1. d, iodine-131
2. Binding of antigen sinks (e.g., in the spleen)
3. Bone marrow
4. Kidney
5. Fc portion
6. e, all of the above
7. CD20
8. crossfire

9. True or false: ^{90}Y ibritumomab tiuxetan (Zevalin) and ^{131}I tositumomab (Bexxar) are chimeric antibodies to CD20 antigen.

9. False.

10. Contraindications for radionuclide therapy in lymphoma include the following:

a) external beam radiation involving 25% of the bone marrow
b) less than 15% cellular bone marrow
c) prior bone marrow transplant or stem cell transplant
d) platelets less than 100,000 or absolute neutrophil count less than 1,500cells/mm^3
e) known hypersensitivity reaction
f) all of the above

10. f, all of the above

11. An acceptable biodistribution pattern on pretherapy ^{111}In Zevalin scan (optional, not required) at 2 to 24 hours and 48 to 72 hours includes all of the following except:

a) higher lung activity compared to liver
b) decreasing cardiac blood pool
c) less renal activity compared with liver
d) less bowel activity compared with liver
e) tumor uptake

11. a, document tumor always

12. Yttrium-90 can be administered:

a) as an outpatient treatment without restrictions, but with precautions for handling body fluids.
b) only if activity levels are determined prior to release.
c) only as an inpatient treatment.
d) with the same safety precautions that apply for Bexxar treatment without restrictions but with precautions for handling bodily fluids.

12. a

13. True or false: The dose for Zevalin is 0.4 mCi/kg (14.8 MBq) and is decreased to 0.3 mCi/kg (11.1 MBq) if platelets are 100,000 to 150,000, with a maximum dose of 32 mCi (1,184 MBq).

13. True.

14. True or false: If platelets are between 100,000 and 150,000, the desired whole-body radiation dose from Bexxar therapy is decreased from 75rad (75 cGy) to 65 rad (65 cGy).

14. True.

15. True or false: For Bexxar therapy, the dose to be administered is calculated from the clearance rate determined from the dosimetry scans, as the rate varies at least fourfold within the population.

15. True.

16. What radioprotective agents are administered before and after Bexxar therapy?

16. SSKI/Lugol's solution; potassium iodide.

17. What is the physical half-life of strontium-89?

17. 50.5 days.

18. What is the usually administered dose of strontium-89 for palliative therapy of metastatic bone disease?

18. 4 mCi (148 MBq).

19. Which radionuclides used for palliative bone therapy can also be imaged?

a) Samarium-153
b) Rhenium-186
c) Strontium-89
d) Phosphorus-32
e) None of the above

19. a and b

20. Where is radionuclide phosphate utilized for therapy?

20. ^{32}P chromic phosphate is injected into malignant pleural or peritoneal cavities; ^{32}P orthophosphate is injected intravenously for polycythemia vera.

21. True or false: Plastic/acrylic shielding is utilized for ^{90}Y Zevalin; lead shielding should not be used.

21. True.

22. Which radiotracer is administered in the locoregional palliative treatment for unresectable hepatic malignancy through permanent biocompatible glass or resin implants?

a) Yttrium-90
b) Iodine-131
c) Strontium-89
d) Phosphorus-32

22. a, yttrium-90

23. True or false: ^{90}Y spheres are preferentially deposited in the tumor that derives its blood supply predominantly from the hepatic artery as opposed to the normal liver tissue, whose blood comes from the portal vein.

23. True.

24. Which of the following is not a contraindication for ^{90}Y sphere therapy?

a) Markedly abnormal liver function tests, ascites, or clinical liver failure
b) Lung shunt greater than 20%
c) Disseminated extrahepatic malignant disease

24. d, unresectable hepatocellular carcinoma

d) Unresectable hepatocellular carcinoma or chemorefractory liver-dominant metastases
e) A contraindication for angiogram or chemorefractory liver-dominant metastases

25. Which of the following is not the objective of selective internal radiation therapy with ^{90}Y spheres?

a) Contraindications for or refractory to other therapies
b) Bridge to transplant
c) Curative
d) Downstage for other therapies

25. c, curative

26. The purpose of a pretreatment planning phase angiogram and macroaggregated albumin (MAA) scan is as follows:

a) to document selective tumor blush
b) to verify there is no evidence of abnormal visceral distribution
c) coil embolization of adjacent arterial branches to minimize toxicity
d) to evaluate for lung shunting
e) all of the above

26. e, all of the above

27. Treatments for hyperthyroidism includes the following:

a) radioactive iodine
b) antithyroid medications
c) beta blockers
d) surgery
e) all of the above

27. e, all of the above

28. Radioactive iodine of choice for treatment of hyperthyroidism is (are):

a) ^{123}I
b) ^{125}I
c) ^{124}I
d) ^{131}I

28. d

29. Which is (are) true in hyperthyroidism treated with radioactive iodine?

a) Propylthiouracil or methimazole should be discontinued prior to therapy.
b) Breast feeding may be resumed a month after therapy.
c) Beta blockers should be discontinued prior to therapy.
d) There is increased risk of leukemia.

29. a

30. Contraindications for radioactive iodine treatment for hyperthyroidism include:

a) pregnancy or planning to conceive within 6 months
b) lactation
c) coexisting thyroid cancer
d) unable to comply with radiation
e) all of the above

31. Acceptable treatment(s) for Grave's disease in children is (are):

a) methimazole
b) radioactive iodine
c) thyroidectomy
d) propylthiouracil

32. Preparation for a diagnostic iodine scan or remnant thyroid ablation following thyroidectomy in well-differentiated thyroid carcinoma (WDTC) includes which of the below?

a) thyroid hormone withdrawal is not necessary.
b) thyroxine should be withdrawn for 3 to 4 weeks.
c) liothyronine should be withdrawn for at least 2 weeks.
d) Thyrogen can be used in lieu of thyroid hormone withdrawal.

33. Concerning radioactive iodine therapy (RAI) following thyroidectomy for WDTC:

a) RAI remnant ablation therapy is routinely recommended after total thyroidectomy for American Thyroid Association (ATA) low-risk WDTC patients.
b) RAI adjuvant therapy is routinely recommended after total thyroidectomy for ATA high-risk WDTC patients.
c) RAI remnant ablation is not routinely recommended after lobectomy or total thyroidectomy for patients with unifocal papillary microcarcinoma, in the absence of other adverse features.
d) RAI remnant ablation is routinely recommended after thyroidectomy for patients with multifocal papillary microcarcinoma in absence of other adverse features.

30. e, all of the above

31. a, b, c

32. b, c, d

33. b, c

34. Thyrogen (rhTSH) can be used as an alternative to thyroxine withdrawal for remnant ablation or adjuvant therapy in patients who have undergone near-total or total thyroidectomy:

a) in patients with ATA low-risk WDTC without extensive lymph node involvement
b) in patients with ATA intermediate-risk WDTC without extensive lymph node involvement
c) in patients with WDTC of any risk level with significant comorbidity that may preclude thyroid hormone withdrawal
d) Thyrogen (rhTSH) is only recommended for diagnostic scanning and not for remnant ablation or adjuvant therapy

35. Recommended dose of ^{131}I for remnant ablation is:

a) 30 mCi for ATA low-risk thyroid cancer
b) 75 mCi for ATA low-risk thyroid cancer
c) 30 mCi for intermediate-risk disease with lower risk features, i.e., low-volume central neck nodal metastases with no other known gross residual disease or any other adverse features
d) 100 mCi for intermediate-risk disease with lower risk features, i.e., low-volume central neck nodal metastases with no other known gross residual disease or any other adverse features

36. Diagnostic whole-body RAI scans in patient with prior ^{131}I ablation is indicated in:

a) low-risk patients with an undetectable thyroglobulin on thyroid hormone with negative antithyroglobulin antibodies and a negative ultrasound (US)
b) intermediate-risk patients (lower risk features) with an undetectable thyroglobulin on thyroid hormone with negative antithyroglobulin antibodies and a negative US
c) high-risk patients
d) intermediate-risk (higher risk features) patients

34. a, b, and c

35. a and c

36. c and d

37. For thyroid carcinoma pulmonary micrometastasis:

a) treatment of choice is ^{131}I
b) dose can be empirical 100 to 200 mCi
c) retention dose at 48 hours limits to 80 mCi by dosimetry
d) radiation to the bone marrow limits to 200 cGy by dosimetry
e) all of the above

37. e, all of the above

38. Most appropriate management of WDTC patients with metastatic disease include:

a) surgical excision of locoregional disease in potentially curable patients
b) ^{131}I therapy for RAI-responsive disease
c) external beam radiation therapy
d) TSH-suppressive thyroid hormone therapy for patients with stable or slowly progressive asymptomatic disease
e) all of the above

38. e, all of the above

39. Which of the following is (are) considered RAI-refractory WDTC?

a) Metastatic tissue does not ever concentrate RAI.
b) The tumor tissue loses the ability to concentrate RAI after previous evidence of RAI-avid disease.
c) RAI is concentrated in some lesions but not in others.
d) Metastatic disease progresses despite significant concentration of RAI.
e) All of the above.

39. e, all of the above

40. The Food and Drug Administration (FDA)-approved and recommended dose of ^{89}Sr for palliating painful bone metastases is:

a) 1 to 2 mCi (37–74 MBq)
b) 4 mCi (148 MBq)
c) 7 mCi (259 MBq)
d) 10 mCi (370 MBq)
e) 12 mCi (444 MBq)

40. b, 4 mCi (148 MBq)

41. Following treatment with ^{89}Sr, patients should be in isolation for:

a) 24 hours
b) 48 hours
c) 72 hours
d) 5 days
e) isolation is unnecessary

41. e, isolation is unnecessary

42. Of the following, the metastatic bone lesion least likely to respond to ^{89}Sr palliative therapy is:

a) multiple myeloma
b) prostate carcinoma
c) colon carcinoma
d) breast carcinoma

42. a, multiple myeloma

43. The usual administered dose of ^{32}P for treating polycythemia vera is:

a) 1 to 1.5 mCi (37–55.5 MBq)
b) 2 to 5 mCi (74–185 MBq)
c) 5 to 10 mCi (185–370 MBq)
d) 10 to 15 mCi (370–555 MBq)
e) 20 to 25 mCi (740–925 MBq)

43. b, 2 to 5 mCi (74–185 MBq)

44. True or false: The effectiveness of ^{32}P therapy in treating polycythemia vera is generally attributed to the marrow-suppressive effects of its gamma (γ) emissions.

44. False.

45. Besides its use in treating polycythemia vera, some form of ^{32}P has been used to treat:

a) painful bone metastases
b) leukemias
c) malignant pleural effusions
d) all the above
e) none of the above

45. d, all of the above

46. Which alpha emitter is used for treatment of metastatic castration-resistant prostate cancer?

a) Strontium-89
b) Samarium-153
c) Radium-223
d) Phosphate-32

46. c

47. Radium-223 is used for metastatic castration-resistant prostate cancer because it mimics:

a) calcium
b) potassium
c) zinc
d) phosphorus

47. a

48. The most common adverse drug reactions in patients receiving Xofigo are:

a) headache, abdominal pain
b) nausea, vomiting, diarrhea
c) anemia, lymphocytopenia, thrombocytopenia
d) congestive heart failure, pulmonary embolism

49. Half-life of radium-223 is:

a) 11.4 days
b) 110 minutes
c) 6 hours
d) 50 days

48. b and c

49. a

Appendices

A How to Recognize the Whole-Body Scans

Clues to Identification

- Heart activity
- Presence or absence of renal activity
- Cortical bone or marrow uptake
- Relative intensity of liver and spleen
- Time period of imaging if given

Normal Biodistribution

- ^{99m}**Tc-MDP**: Cortical bones, growth plates (in children/adolescents), kidneys, and bladder
- ^{153}**Sm**: Similar to a bone scan
- ^{18}**F-NaF**: Similar to bone scan, but with less noisy appearance
- ^{18}**F-FDG**: Brain, heart (variable), kidneys and bladder, liver, spleen, variable bowel, mild bone marrow
- ^{123}**I-MIBG**: Liver, heart, urinary bladder, salivary glands, mild thyroid, mild adrenal
- ^{67}**Ga**: Liver greater than spleen, lacrimal glands, nasopharynx, cortical bone, renal system (normal only less than 24 hours), lung (normal only less than 24 hours), bowel
- ^{111}**In-WBC**: Spleen greater than liver, marrow, lungs (normal at 4 hours and resolves at 24 hours), no renal activity
- ^{99m}**Tc-HMPAO**: Liver, spleen, marrow, heart, brain
- ^{111}**In-pentetreotide**: Spleen, then liver, renal system, bowel
- ^{123}**I-NaI**: Salivary, gastric, urinary bladder, thyroid (if present)
- ^{131}**I-NaI**: Similar to ^{123}I-NaI, but with noisier appearance
- ^{99m}**Tc–sulfur colloid**: Liver (85%), spleen (15%), marrow (5%). The particle size determines the biodistribution.
- ^{99m}**Tc sestamibi**: Heart, liver, gallbladder, bowel, muscles, renal system
- ^{201}**Tl-thallous chloride**: Heart, renal, lesser liver, and intestinal activity

B Must-Know Calculations, Scintigrams, and Concepts

Must-Know Calculations

- Ejection fraction (EF)
- Half-time
- Effective half-life
- Standardized uptake value (SUV)
- Lung perfusion quantification
- Gastric emptying half-time
- ^{131}I dose calculation
- Radioactive iodine uptake (RAIU)
- Half value layer (HVL)
- Inverse square law
- Activity and number of atoms
- Count average, standard deviation, coefficient of variation
- Full width at half-maximum (FWHM) of the system, intrinsic, and extrinsic
- Integral uniformity
- Percent of energy resolution
- Basic statistics: mean, median, standard deviation, and standard error

Must-Know Scintigram Patterns and Diseases

- Lingual thyroid
- Thyroglossal cyst
- Parathyroid adenoma including ectopic
- Toxic thyroid adenoma
- Subacute thyroiditis
- Multinodular goiter
- Graves' disease
- Neuroblastoma and pheochromocytoma on ^{123}I-MIBG scan
- Shin splints
- Paget's disease
- Abnormal biodistribution on bone scan and corresponding causes
- Stress fracture
- Hypertrophic pulmonary osteoarthropathy (HPOA)
- Hyperostosis frontalis interna
- Avascular necrosis
- Slipped capital femoral epiphysis (SCFE)
- Superscan

- Osteomyelitis
- Cellulitis
- Prosthetic joint infection versus loosening
- Pars interarticularis uptake
- Reflex sympathetic dystrophy (RSD)
- Myositis ossificans
- Dystrophic and metastatic calcifications
- Cold spine defect on ^{111}In-WBC scan
- PCP pneumonia on ^{67}Ga scan
- Discordant ^{67}Ga and ^{201}Tl uptake in Kaposi's sarcoma
- ^{111}In-WBC and ^{99m}Tc-HMPAO in inflammatory bowel disease (IBD)
- Panda sign in sarcoidosis
- Left bundle branch block and stress testing
- Balanced ischemia
- Apical thinning
- Cardiac sarcoid
- Cardiac viability with thallium and ^{18}F-FDG
- Lung activity on thallium in left ventricular failure
- Hot spots on V/Q scan
- Stripe sign
- Fissure sign
- COPD abnormality on lung scan
- Fatty liver on V/Q scan utilizing ^{133}Xe
- Acute cholecystitis
- Bile leak
- Neonatal hepatitis versus biliary atresia
- Rim sign in acute cholecystitis
- Hepatic hemangioma
- Common bile duct (CBD) obstruction
- Discordant hepatic activity and differential of focal nodular hyperplasia (FNH), adenoma, and hepatoma
- Pre-SIRT ^{99m}Tc-MAA scan demonstrating abnormal visceral or lung shunting
- Meckel's diverticulum
- Pelvic/ectopic kidney
- Acute tubular necrosis (ATN) posttransplant
- Pattern of renal transplant rejection
- Renal/urinary leak
- Horseshoe kidney
- Renal scarring and pyelonephritis on DMSA study
- Diuretic renal scintigraphy
- Renal artery stenosis on captopril scintigraphy
- Brain death

- Ventriculoperitoneal shunt study
- Normal pressure hydrocephalus (NPH)
- Seizure study—ictal SPECT and interictal on SPECT and PET
- Brown fat on FDG-PET scan
- Alzheimer's disease (AD) patterns on perfusion and FDG brain images
- AD patterns on brain amyloid images
- Patterns of uptake for parkinsonian syndromes on ^{123}I ioflupane images (DaTscan)

Miscellaneous Important Concepts

- Basic ECG abnormalities and leads
- Errors in MUGA calculation
- PIOPED and Modified PIOPED criteria versus criteria for interpretation of SPECT lung perfusion/ventilation
- Solitary pulmonary nodule: benign and malignant percentages
- Thyroid nodules: benign and malignant percentages
- Quality control: radionuclides, gamma camera, and dose calibrator
- Radiation safety limits for different populations
- Pharmacological and exercise stress testing: indication, contraindication, and end points
- Recognition of various window levels on CT scan
- Basic CT physics
- Collimator: types, applications, and changes in sensitivity and resolution
- Molybdenum-99/^{99m}Tc generator system components and principles of elution
- Off-peak, photomultiplier tube defect, and cracked-crystal images
- Full width at half-maximum (FWHM)
- Nyquist's frequency
- Back-projection and functioning of various filters
- Correct region of interest (ROI) selection for renal and MUGA scans

Further Resources for Cases

[1] Clinical teaching file from University of Kansas Hospital at http://www.rad.kumc.edu/nucmed/clinical.htm
[2] Appelbaum D, Miliziano J, Nayak S, Bradley Y. RadCases Nuclear Medicine. New York, NY: Thieme Medical Publishers; 2011
[3] Digital teaching file from Mallinckrodt Institute of Radiology at http://gamma.wustl.edu/home.html
[4] Ziessman HA, Rehm PK. Nuclear Medicine: Case Review. 2nd ed. Philadelphia, PA:Elsevier/Mosby; 2011
[5] Donohoe KJ, Van den Abbeele AD. Case-Based Nuclear Medicine. New York, NY:Thieme Medical Publishers; 2011
[6] Teaching file from Harvard Medical School at http://www.med.harvard.edu/JPNM/

C Tips on Exam Preparation

Registration Process

- Please refer to the American Board of Nuclear Medicine (ABNM) Web site (http://www.abnm.org) for updated information, as the information below is subject to change.
- Application window starts April 1, and an online application must be submitted along with supporting documents and a processing fee by May 31. Training programs need to submit the supporting documents by July 15. A late application (only for MOC) can be submitted (June 1-30) along with a late fee. The balance of all fees is due by July 15 (July 31 with a late fee).
- For timetable, fees, application, and documents, refer to the ABNM Web site and FAQ section. After you log in, the ABNM review checklist and email messages will update you on the status of your application.
- Pearson Vue registration for the exam slot usually begins August 7 for the exam in October.
- Register immediately, because the slots are used by multiple boards and courses and are available only on a first-come, first-served basis.
- Unless you are continuing in a training program approved by the Accreditation Council for Graduate Medical Education (ACGME) (in which case you need a training verification letter and/or a copy of the in-training/institutional license), a state license is required by December 31 to release the examination result. Otherwise, the examination will be null and void. Should you need a state license, remember to start the Federation Credentials Verification Service (FCVS) application and the license application early enough in the year to meet this deadline.
- The content manual and sample questions are available at the ABNM Web site to help in the preparation.

The Day of the Exam

- The examination day is usually during the first week of October, from Monday to Friday, and the slot selection is on a first-come, first-served basis.
- Some Pearson centers offer traditional time slots, while some offer a late morning or afternoon slot. Please check with Pearson at http://www.pearsonvue.com for further details.
- Remember to take the appointment confirmation letter and two identification forms that have your exact name and signature. At least one of them should have a photo.
- Arrive at least 30 minutes prior to the appointment time to permit the check-in and sign-in process.
- The total exam time is approximately 480 minutes for 300 questions (3.5 hours for MOC), including ample time for relaxation breaks (usually about 30 minutes, but check with the proctor at the time of exam). The clock will provide you with the remaining time for the break. You will need to sign in and sign out each time. Try to avoid taking breaks during a block.

Exam Preparation

- The ABNM pass rate statistics are as follows for initial certification and MOC exams: 2006 (84% and 97%), 2007 (86% and 97%), 2008 (76% and 98%), 2009 (87% and 98%), 2010 (82% and 99%), 2011 (66% and 100%), 2012 (84% and 99%), 2013 (79% and 97%), 2014 (81% and 96%), 2015 (78% and 98%), and 2016 (80% and 97%).

- Refer to the article "Components of Professional Competence for Nuclear Medicine Physicians" in the Journal of Nuclear Medicine 2003;44(6):988–990 and to the content manual at the ABNM Web site.
- Some resources for preparation include the following: Donohoe KJ, Van den Abbeele AD, Case-Based Nuclear Medicine, 2nd ed., New York, NY: Thieme Medical Publishers, 2011; Ziessman HA, O'Malley JP, Thrall JH, Nuclear Medicine: The Requisites, current edition; Mettler FA Jr and Guiberteau MJ, The Essentials of Nuclear Medicine Imaging, current edition; and Ziessman and Rehm, Nuclear Medicine: Case Review Series, current edition; the board exam preparatory course on Saturday and Sunday at the Society of Nuclear Medicine (SNM) annual meeting; and the in-training service examination.
- Start your preparation early in the year.
- Know all the Aunt Minnie cases.
- Try to spend at least 1 week shadowing the nuclear medicine technologists. Pay attention to quality control. Try to ask and learn as much as you can. This can be your edge on the examination and in future practice.
- Standard training should make you clinically competent and ready for the exam. Supplement your knowledge of radiation safety and precautions, and nuclear medicine regulations. This additional preparation could help you ace the examination.
- Always pay attention to the edges of the images, artifacts, mechanism of uptake, altered biodistribution, false-positives and false-negatives, limitations, and appropriate recommendations for a given study.
- Emphasize recognition of the normal biodistribution of various radiotracers.
- Know the basics of computed tomography (CT) physics, since CT scan is an integral part of the PET-CT study.
- Learn all the basic and simple calculations and how to perform them on a computer/calculator. These are integral to everyday practice, and you have a high likelihood of being tested on this area during the examination.

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