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SELF-STUDY TEST

Skeletal Nuclear Medicine

Questions are taken from the *Nuclear Medicine Self-Study Program 1,* published by The Society of Nuclear Medicine

DIRECTIONS

Items 1-10 consist of five lettered headings followed by a list of numbered phrases or statements. For each numbered phrase or statement, select the one lettered heading that is most closely associated with it. Each lettered heading may be selected once, more than once, or not at all. Answers may be found on page 952.

For each bone-seeking agent (items 1-4), select the moiety (options A-E) for which it substitutes in the hydroxyapatite crystal.

A. Calcium
B. Phosphate
C. Magnesium
D. Hydroxyl
E. Sulfhydryl

1. ^{99m}Tc diphosphonate
2. ^{18}F fluoride
3. ^{99m}Tc pyrophosphate
4. ^{87m}Sr

For each of the ^{99m}Tc MDP images shown in Figures 1, 2 and 3 (items 5-7), select the most likely mechanism for the nonosseous localization of the radiopharmaceutical (options A-E).

A. Excessive free reduced ^{99m}Tc in the radiopharmaceutical, with colloid formation
B. Metastatic calcification
C. Heterotopic ossification
D. Dystrophic calcification
E. Increased local concentration of tracer

5. Figure 1
6. Figure 2
7. Figure 3

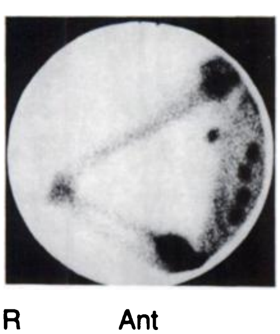

Figure 1

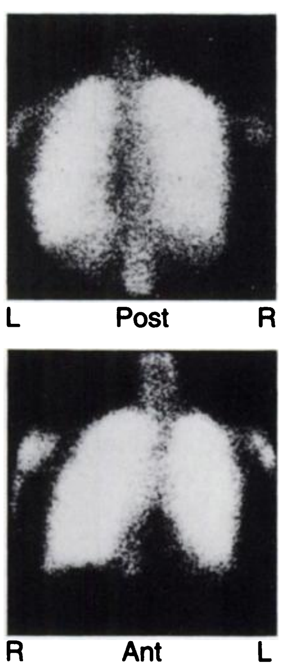

Figure 2

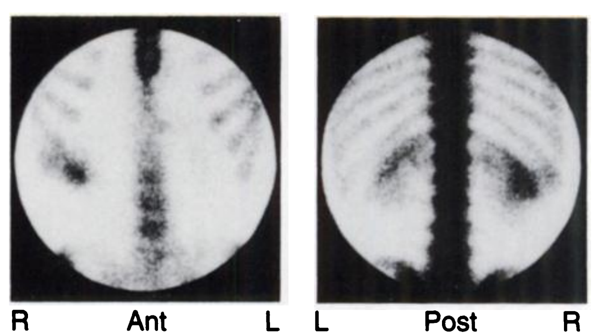

Figure 3

(continued on page 952)

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SELF-STUDY TEST
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QUESTIONS *(continued)*

Figures 4, 5 and 6 illustrate radiographs of the lumbar spine and bone mineral images obtained with a dual-photon bone mineral analyzer. For each figure (items 8-10), select the best description or interpretation of the findings (options A-E).

A. Machine-produced artifact is apparent in this study.

B. Aortic calcification, hypertrophic changes in the facet joints and wedging of L2 result in mildly inhomogeneous bone mineral distribution. A smaller than usual region of interest should be used.

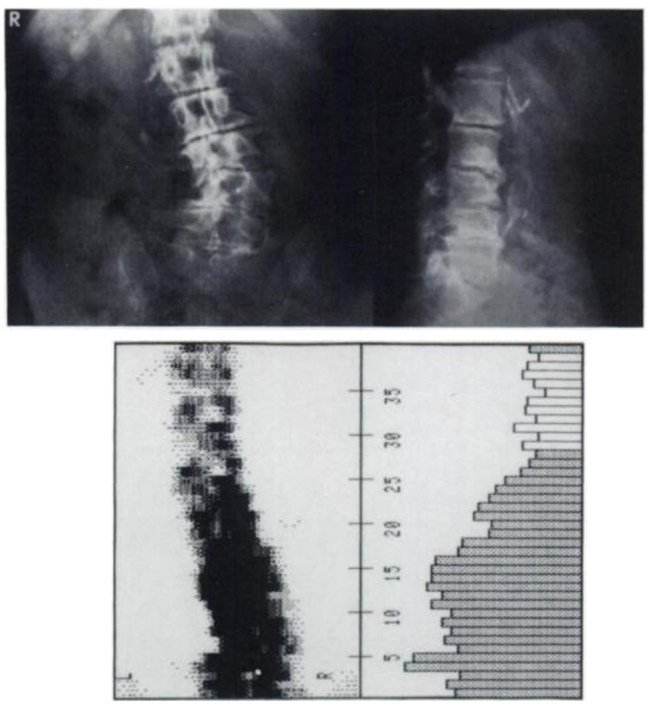

Figure 4

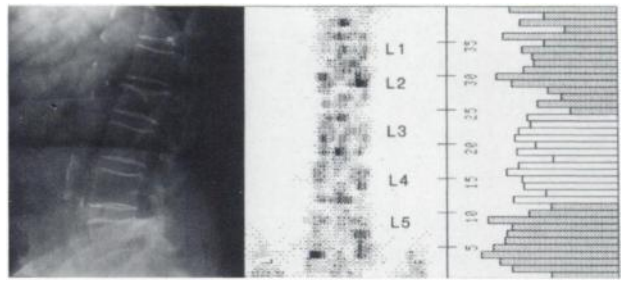

Figure 5

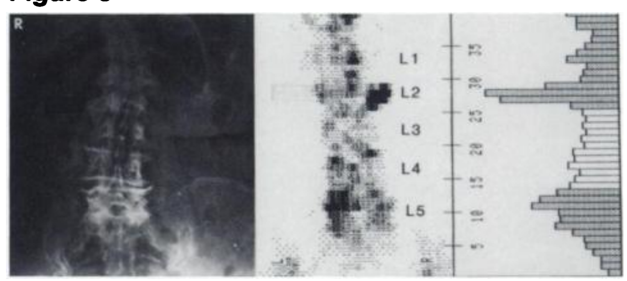

Figure 6

C. Significant scoliosis and post-traumatic changes are present in the lumbar spine. If bone mass assessment is necessary, it should be performed at the hip or a peripheral site, such as the radius or calcaneus.

D. Major degenerative changes are present in the lumbar spine. A region of interest smaller than the standard L2 to L4 region should be used.

E. There is evidence for reduced bone mineral density in the lumbar spine. The findings are more likely due to osteomalacia than to osteoporosis.

8. Figure 4
9. Figure 5
10. Figure 6

SELF-STUDY TEST
Skeletal Nuclear Medicine

ANSWERS

Items 1-4: Bone-Seeking Radiopharmaceuticals

Answers: 1, B; 2, D; 3, B; 4, A

The phosphate moieties in the condensed polyphosphates (including pyrophosphate) and the diphosphonates provide oxygen atoms, which allow binding to calcium atoms in hydroxyapatite. The exact nature of their chemical binding (and that of the associated technetium) to bone crystal has not been elucidated. The fluoride ion exchanges for hydroxyl groups in hydroxyapatite because of similarities in charge and size of this monovalent anion with those of the hydroxyl ion. Strontium is in Group II of the Periodic Table, along with calcium, and radionuclides of strontium, as well as those of barium and radium, are capable of substituting for the divalent calcium cation in hydroxyapatite crystals.

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SELF-STUDY TEST
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ANSWERS *(continued)*

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Items 5-7: Nonosseous Localization of ^{99m}Tc MDP

Answers: 5, E; 6, B; 7, D

Figure 1 shows accumulation of ^{99m}Tc MDP in an axillary lymph node and extravasation of the radiopharmaceutical about the injection site near the wrist. Incidentally noted are foci of increased activity in multiple right anterior ribs, most likely due to fractures. Increased activity in normal axillary lymph nodes ipsilateral to the site of a partially extravasated injection is a common finding on bone scintigraphy and has been confirmed in animal studies. Occasionally, the lymphatic channels containing the tracer in increased concentration also are seen. The mechanism of "retention" of the tracer in the lymph nodes is not entirely clear, but colloid formation (either in the radiopharmaceutical preparation or subsequently in vivo) does not appear to be a prerequisite. In most cases, no hepatic or splenic uptake is seen. Most likely, the higher concentration of ^{99m}Tc MDP in the larger volume of lymph in the node (relative to surrounding soft tissues) accounts for its scintigraphic visualization.

Figure 2 shows markedly increased, diffuse pulmonary uptake of ^{99m}Tc MDP. The most likely cause of this appearance is metastatic calcification, which occurs in hypercalcemic or hyperphosphatemic states when the solubility product for calcium and phosphate is exceeded, leading to deposition of calcium phosphate salts in the extracellular spaces of various soft tissues. The phenomenon is seen in patients with chronic renal failure, hyperparathyroidism, the milk-alkali syndrome, vitamin D intoxication and with hypercalcemia due to neoplastic involvement of the skeleton (metastases, myeloma). Increased tracer accumulation also may be seen in the heart, stomach and kidneys, as well as in the lungs.

Figure 3 illustrates a discrete focus of ^{99m}Tc MDP accumulation in the right upper quadrant of the abdomen, which is both lateral and anterior to the right kidney and, thus, not due to retained pelvicalyceal activity. The most likely explanation for this finding is tracer uptake in a hepatic metastasis that is undergoing either intra- or extracellular calcification. This type of calcification, which most likely is related to necrosis within the tumor deposit, should be considered a form of dystrophic calcification. Unlike metastatic calcification, which occurs as a result of systemic alterations in calcium and phosphate homeostasis, dystrophic calcifications occur at sites of injury (from many different mechanisms) in soft tissues. The primary tumor most often giving rise to "hot" hepatic metastases is adenocarcinoma (especially mucinous) of the colon, but dystrophic calcification has been seen in the metastatic regions of a wide variety of other neoplasms and also occurs in some hepatomas.

If there were excessive free reduced ^{99m}Tc in a preparation of ^{99m}Tc MDP with formation of colloid, the expected scintigraphic finding would be a generalized increase in hepatic and splenic uptake.

Heterotopic ossification includes localized myositis ossificans, which is usually post-traumatic and occurs adjacent to a long bone, and the new bone formation in the soft tissues, most often about the hips, occurring in association with spinal cord injuries, other neurologic disorders and burns. It also occurs as part of a rare hereditary disorder known as myositis (fibrositis) ossificans progressiva.

References

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Items 8-10: Evaluation of Bone Mineral Analyses

Answers: 8, C; 9, B; 10, D

A review of the bone mineral tracing is an important part of the interpretation of bone mineral measurements. Figure 4 shows radiographically evident scoliosis and post-traumatic changes in the lumbar spine, which will make bone mineral results from this site difficult to interpret, even if a more superior region of interest is used (e.g., T12, L1). In such cases it is best not to use the lumbar spine as the site of measurement, and to use the hip, the radius or calcaneus instead.

Figure 5 shows degenerative changes in the facet joints, aortic calcification and wedging of L2 on the radiograph, and inhomogeneous distribution of bone mineral in the bone mineral image. The region of interest for bone mineral measurements should exclude L2.

The findings in Figure 6 best correspond to the description in option D. Generally, 10%–15% of women over 65 years of age have significant degenerative or postoperative changes, or have compression fractures in the standard measuring site. In most of these cases, modification of the standard region of interest becomes necessary or another site has to be selected. The error of the method, with respect to both precision and accuracy, increases when the region of interest is smaller. The smallest region of interest used probably should not be less than two vertebrae or about ten scanning lines. Dual-photon absorptiometry detects osteopenia but does not distinguish the multiple causes of decreased bone mineral density from each other.

For further in-depth information, refer to the syllabus pages in Nuclear Medicine Self-Study I.