TEACHING EDITORIAL

Quantification of Skeletal Tc-99m Labeled Phosphates to Detect Metabolic Bone Disease

As a highly sensitive indicator of disturbed bone metabolism, the Tc-99m-labeled phosphates have dramatically established their role in the clinical assessment of bone disease. Focal skeletal concentrations of these radipharmaceuticals in other than normal sites of uptake infer abnormality, and from either their pattern of distribution or their associated clinical and chemical alterations a reasonable and usually accurate diagnosis can be made. In instances where the disease affects the entire skeleton, such as the metabolic bone diseases (Table 1), the Tc-99m-labeled phosphate image may not be as informative and is usually indistinguishable from the normal skeletal image. Characteristically, in the metabolic bone diseases the rate of bone metabolism is greater than normal, and this should be detected by quantifying the skeletal concentration of the Tc-99m-labeled phosphates, since their uptake is proportional to this activity.

For their work published in this issue of the *Journal*, Fogelman and his associates (*1*) used a conventional whole body counter to determine the sequential body retention of Tc-99m HEDP in patients with metabolic bone diseases. The groups included Paget's disease, renal osteodystrophy, osteomalacia, primary hyperparathyroidism, and osteoporosis. Using approximately 1/300 of the usual imaging dose of Tc-99m HEDP and measuring their whole-body retention at 24 hr, Fogelman et al. were able to clearly separate all of the groups, except the osteoporosis, from the normal controls. It is quite possible that their failure to distinguish the small osteoporotic group, who were all clinically symptomatic with multiple fractures, was influenced by the increased concentration of the radiopharmaceutical at the fracture sites. They also compared these results in the same patients to their serial blood count activity (clearance) and their 4-hr bone-to-soft tissue ratio using the second lumbar vertebrae and the contiguous paraspinal soft tissue activity. Although moderate intra- and intergroup differences were observed in the blood activity at various samplings, none were persistent and, as anticipated, only the renal osteodystrophy patients gave consistently high values. The results of the bone-to-soft tissue ratio measurements were similar to those reported by Sy et al. (*2, 3*) and showed scans of patients with primary hyperparathyroidism and osteoporosis to be indistinguishable from those of normal controls.

The advantages of whole body counting to differentiate the metabolic bone diseases seem obvious. The lower radiation dose, the rapid measurement, the excellent reproducibility, and the accuracy in sharply separating the diseases, particularly the primary hyperparathyroid patients, make it a desirable diagnostic procedure. Unfortunately, the procedure is impractical because the means to perform such studies are limited to only a few centers. By comparison, neither the blood clearance studies nor the regional bone-to-soft tissue ratio show comparable sensitivity, and the often difficult to diagnose hyperporathyroid and the occasional osteoporotic patients go undetected by these procedures.

In a paper given at the Third International Symposium on Nuclear Medicine in 1975 (*4*), we reported the results of a quantitative regional bone-to-soft tissue ratio technique that clearly separated the osteoporotic patient from the normal controls and other patients with focal and metabolic bone diseases. Like Fogelman, we measured lumbar vertebrae activity but chose to quantify the activity of the renal parenchyma at 3 hr to give us a spine to kidney ratio. Earlier studies in patients with normal renal function had revealed relatively uniform renal activity of Tc-99m polyphosphate and Tc-99m diphosphonate at 3–5 hr. The ratios were much higher in the patients with Paget's disease, secondary hyperparathyroidism, and renal osteodystrophy, but much less discriminating between the groups.

Because whole-body retention measurements of the Tc-99m labeled phosphates do differentiate the major nonesoteric metabolic bone diseases, and since qualitative imaging provides only a fraction of the needed diagnostic information, a compromise should be reached. Obviously, regional quantification is a reasonable alternative and is available wherever a 'state of the art" scintillation camera exists. In

TABLE 1. Metabolic Diseases of Bone

A. **Abnormal resorption and/or proliferation**
1. Paget's disease of bone
2. Osteopetrosis
3. Hypophosphatasia
4. Melorheostosis
5. Osteopoikilosis
6. Engelmann's Disease
7. Pachyostosis
8. Osteogenesis imperfecta

B. **Defective Mineralization**
1. Rickets
2. Osteomalacia

C. **Defective Hormonal Secretion**
1. Acromegaly
2. Hypercortisonism
3. Hyperparathyroidism 1° and 2°
4. Hypoparathyroidism
5. Pseudohypoparathyroidism
6. Hyperthyroidism

D. **Decrease Bone Matrix**
Osteoporosis
1. Juvenile
2. Idiopathic
3. Post menopausal
4. Senile

patients without renal disease and suspected of being osteoporotic, the vertebral-to-kidney ratio might be employed to detect and monitor the course of the disease. When metabolic bone diseases on the other end of the spectrum (proliferative) are suspected, with or without renal diseases, paraspinal soft tissue activity-to-bone ratio would be more appropriate and probably diagnostic. Whichever, the need for simplistic quantification is essential in differentiating these diseases and we can only anticipate the innovations yet to come to further improve our diagnostic abilities.

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REFERENCES

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