USE OF RADIOISOTOPE TECHNIQUE AND PHOTON ABSORPTIOMETRY TO DETECT EARLY AVASCULAR NECROSIS

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The exact aetiology of bone necrosis in post-transplant patients remains an enigma [1]. As the incidence of bone disease, including avascular necrosis of bone (AVN) is fairly high (11%) [2], and the morbidity considerable, any method that would be helpful in diagnosing early AVN would be of immense benefit in these patients. Since the magnitude of resorption necessary to ensure X-ray visualisation is great we decided to adopt newer methods to detect early AVN.

Patients and Methods

Technetium 99m sulphurcolloid (TcSc) was used as an index of perfusion and technetium 99m diphosphonate (TcDP) was used as an index of osteoblastic activity. Hip images were made with a Searle HP-IV Scintillation camera or Picker rectilinear scanner. Presence or absence of TcSc uptake was taken as evidence of vascularity or avascularity respectively. Increased uptake of TcDP was taken as evidence of increased osteoblastic activity associated with aseptic necrosis in the absence of history of trauma or of arthritis. We felt both these studies were complementary in diagnosing AVN. Thirty-two patients were studied with TcSc, 16 of which were also studied with TcDP. Each patient was studied twice and received 10 mCi of $^{99mTc}$Sc and $^{99mTc}$DP intravenously one to four weeks apart. Between one and two hours after administration, hip images were obtained with a scintillation camera with a diverging head collimator in order to visualise both hips simultaneously.

The photon absorptiometry technique, whereby bone mineral content was measured by monoenergetic gamma photon absorptiometry over the os calcis and radius with the use of a rectilinear scanner, was described earlier by our group [3]. Measurements were done on a 2" segment of the central portion of the left os calcis and of two positions on the ulna and radius of the right forearm — the distal one inch and a one-half inch segment at the junction of the middle and distal third of the forearm. This study was carried out on 25 patients
on 75 occasions. The data was stored on magnetic tape and computed using a PDP8E computer to express mineral content in g/cm and g/cm².

Results

Bone Scanning

Of 32 symptomatic patients studied, 11 patients showed a characteristic pattern of decreased perfusion with TcSc and increased bone uptake with TcDP; thus diagnosing AVN. Five of these patients had radiological evidence of AVN and six others, in spite of having persistent symptoms, had no radiological evidence of AVN, even though X-rays including Clayton-Johnson views were repeated on several occasions. Following conservative management [1], symptoms improved in these six patients.

Bone Densitometry

Of 25 patients studied, 18 patients had no significant bone loss. Bone mineral loss was significant in seven patients all of whom had already or soon thereafter developed the clinical and radiological picture of AVN. The 18 patients with normal bone density have failed to show radiological signs of AVN even after three years of follow-up.

Discussion

Aseptic necrosis of bone, especially in weight bearing joints, is a well-known complication in renal transplant recipients. We suggested earlier that this complication is secondary to persistent secondary hyperparathyroidism [4]. Other suggested pathogenetic factors include steroid-induced osteoporosis, ischaemia of bone due to fat embolism, and hypophosphataemic osteomalacia. This study was directed towards diagnosis of AVN at a very early stage, thereby possibly avoiding surgical intervention.

TcSc is concentrated into active and perfused marrow. Since the femoral head contains bone marrow, if the activity is equal to the background it indicates that there is normal blood supply. If the activity is greater than the background, there should be adequate perfusion to prevent necrosis. Conversely, if activity in the region of the femoral head/neck is less than the background, it indicates absent reticuloendothelial cell activity presumably due to absent blood flow. The bone attenuates the background activity, accounting for the photon deficient area. A supplementary benefit of TcSc is the ability to demonstrate revascularisation. Two of the patients had an improved uptake following a revascularisation procedure (muscle-pedicle graft).

Diphosphonate tagged with ⁹⁹ᵐTc gives satisfactory bone images with a relatively low radiation dose. After injection, diphosphonates are 'chemisorbed' into the bone, which leads to a mononuclear layer without toxic effects. Areas of increased bone turnover will concentrate the diphosphonates more actively. Patients with AVN have absent bone marrow activity and increased cortical
bone activity, while patients with degenerative joint disease have parallel (they are either both increased or decreased depending upon activity of the arthritis or decreased use of the joint) bone marrow and cortical activity. We studied 32 patients who had symptoms of pain and discomfort of which 11 had AVN as diagnosed by decreased perfusion in TcSc and increased uptake of TcDP. Six of the patients were treated conservatively with good results and, thus, a potential cause of serious morbidity was avoided.

One of us (JMV), in the early 1970s, during the Apollo and Skylab missions, employed an essentially monoenergetic photon source ($^{125}$I) and a scintillation detector to measure bone mineral by the absorptiometric technique. The standard procedure was modified to obtain more reliable data by the use of a rectilinear scanner which allows measurements over somewhat larger portions of bone than standard single pass photon absorptiometry and thereby allows more exact re-positioning of the measurements for longitudinal studies. Whereas bone mineral content can be measured with high precision, morphological characteristics of the bone cannot be determined by this technique. We studied 25 patients by this technique, 18 of whom had no significant bone loss. This latter group had no symptoms or signs diagnostic of AVN. Bone mineral loss was found to be significant in the seven patients who either had overt AVN or developed AVN soon after. This suggests that if bone mineral content is returned to normal, the possibility of developing AVN becomes less. Metabolic bone disease, especially in renal osteodystrophy, is not uniform in nature, and therefore, this study is not claimed to evaluate total body bone loss. We studied the os calcis as an indicator of the status of weight-bearing bone, and the radius as an indicator of non-weight bearing bone.

**Conclusions**

1. Radioisotopic techniques may prove to be a practical and non-invasive method of assessing femoral head circulation and predicting AVN early, which could significantly reduce the morbidity of the disease.
2. Photon absorptiometry is a simple, safe, accurate, and reproducible test to evaluate the bone mineral status of an individual.

**References**