The Journal of
Bone and Joint Surgery

EDITORIALS AND ANNOTATIONS

BONE SCANNING IN ORTHOPAEDICS

Isotopes of calcium and strontium have been used to study bone metabolism since 1942 when they were first shown to concentrate in bone tumours (Treadwell, Low-Beer, Friedell and Lawrence 1942), but it is only within the last twelve years (Bauer and Ray 1958) that external counting techniques have found a place in clinical orthopaedics. Using one of the gamma-emitting, bone-seeking isotopes, these techniques can be used to build up a picture of the distribution of isotope within the skeleton, the main essential being a highly collimated crystal detector with which areas of increased activity can be accurately located. The detector is moved manually or automatically in rectilinear fashion over part or over the whole of the patient, and the pulses can be recorded either numerically or as a visual display using coloured dots or by means of a variable light source projected on to photographic film. If this scan is then superimposed on a radiograph of the skeleton, it gives a composite picture of isotopic activity in bone, and abnormalities show up as points of increased uptake when compared with a normal contralateral or adjacent site. Normally there is increased concentration of the isotope at certain sites, and these need to be known if the scan is to be interpreted correctly. A normal bone scan shows increased radioactivity at the ends of long bones, in the vertebrae, around the acetabula and sacro-iliac joints, and in the carpal and tarsal bones (DeNardo and Volpe 1966). Use of the gamma camera in bone studies has proved disappointing partly because of the high energy of the isotopes used.

The ideal isotope for bone scanning must fulfil a number of requirements. A large proportion of the dose must be concentrated in bone and the remainder excreted as rapidly as possible. This process should take place quickly so that a short-lived isotope can be used. It should emit a gamma-ray with an energy between 80 and 600 KeV, high enough to reach the detector efficiently but not so high as to prevent good collimation; it should also emit as little beta radiation as possible, in order to minimise the radiation dose to the patient. By using an isotope with a short half-life and one which is rapidly excreted, the exposure time can be limited and the radiation dose to the patient can be kept low.

Strontium-85 has been widely used for bone scanning: its long half-life (sixty-five days) enables scans to be performed after full incorporation into bone has taken place and when the masking effect of radiostrontium in the circulation is no longer a problem. (It is calculated
that 55 per cent of the dose is excreted by the fifth day, the remainder being permanently fixed to the skeleton (DeNardo and Volpe 1966). Since the introduction of the shorter-lived isotopes, strontium-87m (2.8 hours) and fluorine-18 (1.8 hours), they have largely supplanted strontium-85 for bone scanning in this country. A larger dose can be administered, thus allowing high enough count rates for the detection of small lesions, and the radiation dose to the skeleton is considerably less (0.15 rad from 1 mc. of strontium-87m compared with 5 rads from 0.1 mc. of strontium-85 (Weber et al. 1969)).

Strontium-87m is obtained by "milking" from a generator, but fluorine-18 can only be obtained direct from a cyclotron and its availability is therefore limited. However, Weber and his colleagues (1969) came to the conclusion that fluorine-18 was the most suitable short-lived isotope for bone scanning, although high activity in the urine can cause confusion when scanning the pelvis (French and McCready 1967). A recent report on the use of barium-131 in bone scanning (Spencer, Lange and Treves 1970) suggests that its 11.6 day half-life may render it a useful isotope in this field. Good scans can be obtained with both strontium-85 and strontium-87m even though much of the strontium-87m is still in circulation at the time of the scan. This can sometimes give rise to false negative results due to masking, or to a false positive when an area of increased vascularity mimics a bone lesion (Charkes 1969). There may also be good theoretical reasons for preferring strontium-85 because a scan carried out after complete equilibration should give a truer picture of bone pathology. Despite this, however, it is unlikely that the Isotope Advisory Panel of the Medical Research Council will allow the use of strontium-85 in non-malignant disease in Britain now that less hazardous isotopes are available.

Increased bone uptake occurs in many clinical conditions, in areas of high bone-tissue turnover with reactive bone formation. A scan can detect bone lesions before radiological signs can be detected, because it is dependent only on an increased rate of mineral formation, and not on the actual amount of mineral laid down. It is stated that 30 to 50 per cent of bone calcium in a local area must be altered before radiographic changes are evident (Borak 1942). Later on in the process, when radiological changes are already established, osteoblastic activity may have fallen and the scan becomes negative. For this reason, scanning has been widely used for the early detection of metastases, either as a screening procedure or to determine the cause of localised pain in a patient with malignant disease when no abnormality has been seen in the radiographs. It can be helpful in determining the full extent of a bone lesion which may appear as only a small radiological abnormality (Charkes, Sklaroff and Young 1966). If a malignant bone lesion fails to take up isotope, then this is regarded as a sign of inactivity. In a study of twenty-six cancer patients by Greenberg et al. (1968), bone lesions were detected by scanning thirty-four to 146 days before their appearance radiologically.

In primary bone tumours Harmer and colleagues (1969) found that scans rarely gave more information than that obtained from good quality radiographs, but were useful in detecting recurrent tumour after treatment by irradiation. Increased uptake is seen in the malignant reticuloses, but not usually in myeloma. Benign bone tumours are less likely to take up isotope, and bone islands can be distinguished from osteoblastic metastases by scanning (DeNardo and Volpe 1966). In Paget's disease very high levels are recorded over involved bones. Unfortunately radioisotope methods cannot differentiate between benign and malignant lesions, and scanning does not help when malignant change supervenes in a case of Paget's disease (Spencer et al. 1967).

In osteomyelitis, in the early stages before the radiographic appearance becomes abnormal, a positive scan can frequently be obtained (DeNardo and Volpe 1966). Similarly the full extent of an infective lesion may not be appreciated until isotope measurements have revealed its full extent. Scanning can be of particular value in assessing activity in cases of tuberculous or pyogenic spondylitis, and as a complement to the usual clinical and radiological assessment (Felländer and Lindberg 1966). On the whole there is good agreement between the clinical
findings and the scan, high uptake indicating an active infective process and normal uptake indicating a healed or quiescent lesion. The vexed question of reactivation in an old area of infection may sometimes be answered by means of a scan; it may also be possible to differentiate pyogenic from tuberculous osteomyelitis (Bauer 1968).

Scanning techniques have also been used in the investigation of fractures. Wendeburg (1961) showed that uptake over a fracture site reached its highest levels many months after the fracture, and that the values had not returned to normal even six years afterwards, although the radiograph might by then be normal, indicating that repair of the finer structure was still not complete. Scanning may have a part to play in the early diagnosis of fatigue fractures of the femoral neck, in assessing viability of the femoral head in transcervical fractures and in the differentiation between traumatic and osteoporotic fractures of vertebrae (Bauer 1968).

Increased levels of uptake associated with an increased rate of bone-tissue turnover are found in osteoarthritis, often preceding any radiographic change. In some elegant studies on the knee joint, Bauer and his colleagues in New York (Bauer and Smith 1969) produced convincing evidence that uptake is higher in areas of greater osteosclerosis because of the higher rate of mineral and bone-tissue turnover in these areas. Bauer also investigated patients with non-traumatic necrosis of the head of the femur and recorded abnormally high levels of uptake, sometimes before radiographic changes were seen. The high concentration of isotope in osteonecrosis is probably due to a repair reaction starting at the margin of the necrotic bone. In this issue Muheim and Bohne report on fifty-one patients in whom they applied the same technique to the study of spontaneous osteonecrosis of the knee, and used it to differentiate between primary osteoarthritis and arthritis secondary to osteonecrosis. They conclude that isotope uptake measurements may have considerable value in predicting the outcome in cases of osteonecrosis, and these in turn can be useful in deciding between conservative treatment or more radical measures.

Scintillation scanning is a tool which is only just beginning to be used in orthopaedics and has not yet reached the level of sophistication of diagnostic radiology except in a few specialised centres. But it has already proved its worth in a number of clinical situations, notably in the early diagnosis of metastases and in osteomyelitis, and it is likely that it will have an increasing part to play in the management of many orthopaedic conditions.

NICHOLAS GODLEE.

REFERENCES


CHARKES, N. D. (1969): Some Differences between Bone Scans made with 87m Sr and 85 Sr. Journal of Nuclear Medicine, 10, 491.


