STRONTIUM $^{87m}$SR BONE SCANNING FOR THE EVALUATION OF TOTAL HIP REPLACEMENT


From the Departments of Orthopaedic Surgery and Nuclear Medicine, University Hospital, Nijmegen

In a series of seventeen patients with unilateral osteoarthritis of the hip a scintiscanning follow-up study was made before and after total hip replacement for the assessment of the normal course of the $^{87m}$Sr-scintiscan. In another series of twenty-eight patients with total hip replacement a photoscan was made as a supplement for the diagnosis of loosening of one or both components of a total hip implant. In most of these cases it proved to be a useful method, especially when clinical and radiological examination was inconclusive. It is concluded that up to six months after operation increased osteoblastic activity exists; the scintiscan became normal after that time. $^{87m}$Sr scintiscanning offers a safe and simple technique for the assessment of the success and stability of total hip arthroplasty. It is also a useful aid for the early detection of loosening and infection. The procedure can help in the differential diagnosis of complaints after total hip replacement.

In the past ten years, total hip arthroplasty has become the most accepted surgical procedure for the treatment of advanced osteoarthrosis of the hip, necrosis of the femoral head, rheumatoid arthritis of the hip, and resectable tumours of the proximal femur and acetabulum (Chapchal 1973).

The most serious complication of the operation is loosening of one or both components of the prosthesis from infection, inadequate cementing or foreign body reaction. Rarely this complication may occur soon after operation, but more frequently it is a late manifestation (Charnley 1972).

The surgeon is usually confronted with patients in whom the implant fixation has been apparently stable for a few years but who then complain of the sudden onset of pain on walking. The diagnosis of a loose prosthesis may be established by means of radiographic examination in abduction and adduction with and without traction, by arthrography, by needle aspiration for culture, and by serial erythrocyte sedimentation rates.

Since loosening of a total hip prosthesis is a gradual and slow process, radiographic and clinical diagnosis tend to be delayed. Early diagnosis is of great importance, firstly in order to control infection when present and secondly because a loose prosthesis leads to progressive bone resorption which, if neglected, may make revision difficult or even impossible.

In recent years, the well-established technique of radionuclide scintigraphy has been employed in the early detection of infection after hip arthroplasty (Venohr, Groher and Klems 1972; Bauer, Lindberg, Naversten and Sjöstrand 1973). The purpose of this paper is to report an investigation of $^{87m}$Sr scintigraphy in assessing the normal course after total hip replacement and in the early detection of loosening of the prosthesis.

CLINICAL MATERIAL AND METHOD

Two groups of patients were studied independently. Group 1 comprised seventeen patients with unilateral osteoarthritis of the hip who were studied before operation and serially after replacement arthroplasty. Studies were performed after one week, monthly for six months, and at the ninth month after operation. Each study included radiographic examination, $^{87m}$Sr scintiscan, and erythrocyte sedimentation rate. Group 2 comprised twenty-eight patients who had undergone total replacement arthroplasty with uneventful post-operative course, who later developed pain about the hip with elevation of the erythrocyte sedimentation rate. These patients were suspected of having a loose prosthesis even in the absence of definite radiological evidence. The time interval between the operation and the suspected diagnosis of loosening of the prosthesis ranged from 0·5 to 4·6 years, with a mean period of 2·1 years. Thirteen of the patients in this group had been operated upon elsewhere and were referred to our institute for examination. Because of the absence of definite radiological changes all patients in this group were studied for evidence of scintigraphic changes. Revision operation was performed in sixteen patients with positive $^{87m}$Sr scintiscan.

Method of study—Scintigraphs were obtained on a Picker Magnascanner 500i with a 7.5 centimetre diameter crystal, and a standard high energy focused collimator. Both do
scans and photoscans were obtained from a 85Sr generator, commercially available from the Radiochemical Centre, Amersham, England. The 85Sr activity is obtained by eluting the generator with sterile 0-005 per cent citric acid solution. The activity dose is measured in a Nuclear-Chicago Medicadose calibrator. An intravenous dose of 3 mCi is administered to the patient. The scan is performed about one hour after the injection. Patients are instructed to empty the bladder before the scan to minimise interference from bladder activity. The patients are scanned in the supine position and the detector range is adjusted to cover the bony pelvis, both hip joints and the upper thirds of both femora. Depending on the count rate a scan ranges between forty-five and sixty minutes.

85Sr is a radionuclide with a physical half life of 2.8 hours. It emits a monoenergetic gamma radiation 388 keV. Strontium is metabolised in the body as calcium. It is fixed in the bone tissue through osteoblastic activity. Bone activity can be detected a few minutes after the injection, but a period of one hour is allowed to reduce the level of relative soft-tissue activity (Scherr, Harbst, Kampmann, zum Winkel, Maier-Borst, Lorenz and Bilianiu 1969).

The scintigraphs are interpreted by comparing density contrast on the photoscan. Increased osteoblastic activity is detected visually as areas of intense photographic density compared to background shades.

RESULTS

Group 1: Normal course after arthroplasty
Serial scintigraphs in this group demonstrated in twelve patients the following pattern of activity changes (Table I). One week after operation diffuse increased activity was seen on the scan in the region of the affected hip. The increased activity was maintained for a mean period of two months (range one to three months). After two months a gradual decrease in the level of activity was observed. After a mean period of 4.3 months (range two to six months), the activity on the affected side was the same as that on the opposite side (Figs. 1 to 5).

Five of the seventeen patients in this group deviated from this pattern (Table II). In four patients, periarticular ossification developed in the region of the gluteal muscles as judged by comparing the scan with the radiograph. The scan activity returned to normal after a period of nine months. The remaining patient showed an unexplained persistently high uptake on the side operated upon. At the sixth month she started to complain of pain on weight-bearing. The scans at six and seven months remained positive (Figs. 6 to 10). At that time radiological examination was also suggestive of a loose prosthesis. At a revision operation looseness of both components of the prosthesis was found, without bacteriological evidence of infection.

Group 2: Patients with suspected loosening
In this group of twenty-eight patients suspected of having a loose prosthesis, twenty-two demonstrated a positive scan (78 per cent) (Figs. 11 and 12). Revision operations were performed in sixteen patients with positive scans. In all these sixteen patients the loosening of the prosthesis was confirmed. In thirteen of the sixteen patients the prediction of the loose component was accurate. Infection was detected in eight of these patients. In six the organism was Staphylococcus albus and in two it was Staphylococcus aureus.

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The remaining six patients out of the twenty-two with positive scans continue to have symptoms and will require further operation. In contrast, the six patients with normal scans have responded to conservative treatment, and their symptoms have gradually disappeared.

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Normal course of scintigraphic pattern. Figure 1—Radiograph of prosthesis after total arthroplasty of right hip. Figure 2—One week before operation. Note the increased osteoblastic activity over the region of the right hip joint. Figure 3—Scintigraphic appearance one month after operation. Note increased osteoblastic activity in the region of the operation. Figure 4—Scintigraphic appearance three months after operation. Note the decrease in osteoblastic activity over the region of the right hip. Figure 5—Scintigraph five months after operation. Return of osteoblastic activity to normal. Note equal background activity right and left.
DISCUSSION

Serial scintigraphic examination of patients after total hip arthroplasty showed a period of enhanced osteoblastic activity caused by formative and resorptive bone remodelling. The average duration of this period was 4-3 months. Under normal circumstances, an equilibrium is reached after this. Osteoblastic equilibrium is indicated by even background activity on the side operated upon. Persistence of increased osteoblastic activity more than five months after operation is a sign of possible complication. Scintigraphic changes precede radiological changes in the detection of loosening.

Similar scintigraphic studies on patients after total hip replacement have already been published (Venohr et al. 1972; Bauer et al. 1973; Nöh and Rettig 1973; Nöh and Akalin 1974; Sjöstrand 1974). Venohr and colleagues (1972) observed that nine months after implantation the
$^{87}\text{Sr}$ scintiscan was stabilised. Nöh and Rettig (1973) reported that infection and loosening could be detected by a positive $^{87}\text{Sr}$ scintiscan. Bauer and colleagues (1973) on the other hand used the long-lived $^{85}\text{Sr}$ radionuclide in conjunction with a scintimetric technique, because of the high radiation dose and the long effective half life of $^{85}\text{Sr}$ repeated follow-up examinations are not possible.

In contrast, the short-lived $^{87}\text{Sr}$ delivers less than 1 per cent of the estimated radiation dose for $^{85}\text{Sr}$ in

The disadvantages of $^{85}\text{Sr}$ scintimetry as a routine clinical procedure are obvious. First, the use of the long-lived radionuclide $^{85}\text{Sr}$ ($T_1/2=\text{sixty-five days}$), delivers a very high dose of radiation to the patient. The estimated radiation dose to bone from an activity dose of 100 microcuries $^{85}\text{Sr}$ is 5 rads, and to the whole body in the order of one rad (I.C.R.P.—Publication 17, 1971). Secondly, the count rate from such an activity dose is too low to permit a significant statistical evaluation of difference in count increments within a reasonable measuring time. Thirdly, equal activities. In our studies a dose of 3 mCi of $^{87}\text{Sr}$ was used. Such an activity dose delivers an estimated radiation dose to bone of less than one rad and about 0.03 rad to the whole body (I.C.R.P.—Publication 17, 1971). The safe but higher activity dose of $^{87}\text{Sr}$ employed permits such a high count rate that the activity distribution can be shown by scintiscanning. Further, repeat examination for follow-up is possible in view of the reduced radiation dose and the short half-life of $^{87}\text{Sr}$.

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REFERENCES


