SOME DIFFERENCES BETWEEN BONE SCANS MADE WITH ^{87m}Sr AND ^{85}Sr

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Because of the rapid skeletal fixation ($\lambda = 0.07$ min^{-1}) and short half-life (2.8 hr) of ^{87m}Sr, bone scans made with this isotope are usually begun 45 min after injection (*1*). Scintigrams of excellent quality are generally obtained with rectilinear scanners despite the fact that 50–70% of the dose is not taken up by bone and remains in the circulation during the scanning procedure (*1,2*). In contrast, scans made with longer-lived ^{85}Sr (half-life 64 days) are performed 48 hr after injection because urinary and fecal losses of unfixed isotope in the interim have sufficiently lowered plasma and extracellular fluid (ECF) levels to significantly increase the target-to-nontarget ratio (*3*). Despite the high body background during the ^{87m}Sr scan, scintigrams of normal and abnormal bones made in patients injected with both isotopes are remarkably similar if not identical, because the nontarget counts are readily suppressed with a contrast control circuit (*1*).

Under certain circumstances, however, the high body background during the ^{87m}Sr scan may result in both false-positive and false-negative scans when compared with ^{85}Sr scintigrams made 48 hr or later after injection. These abnormalities are biologic in nature and cannot always be corrected by alterations in the physical characteristics of the scan image or by refinements in data processing. The purpose of this communication is to illustrate this point with results obtained in two patients recently studied by us.

RESULTS

False-positive. Case 1 (Fig. 1), MR, a 44-year-old-housewife, was found to have multiple myeloma in February 1964 and was treated with urethane, prednisolone and, more recently, with an alkylating agent. Skeletal roentgenograms revealed extensive

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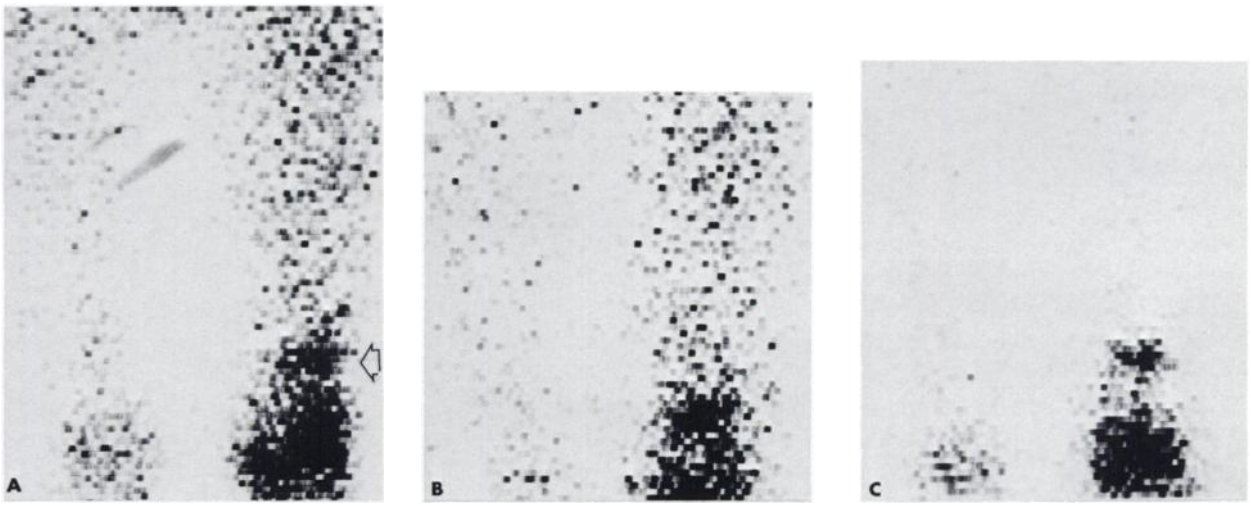

FIG. 1. MR, Case 1: A is scintigram of thighs begun 40 min after intravenous injection of 3.16 mCi ^{87m}Sr. Arrow points to pathologic fracture. Note increase in counting rate along entire left thigh and in femoral condyles. B is ^{85}Sr scintigram of thighs begun 2½ hr after injection of 100 μCi. Scan is indistinguishable from that made with ^{87m}Sr. C is scan made 3 days after ^{85}Sr injection. Note that abnormal activity in left thigh has disappeared in this late scan.

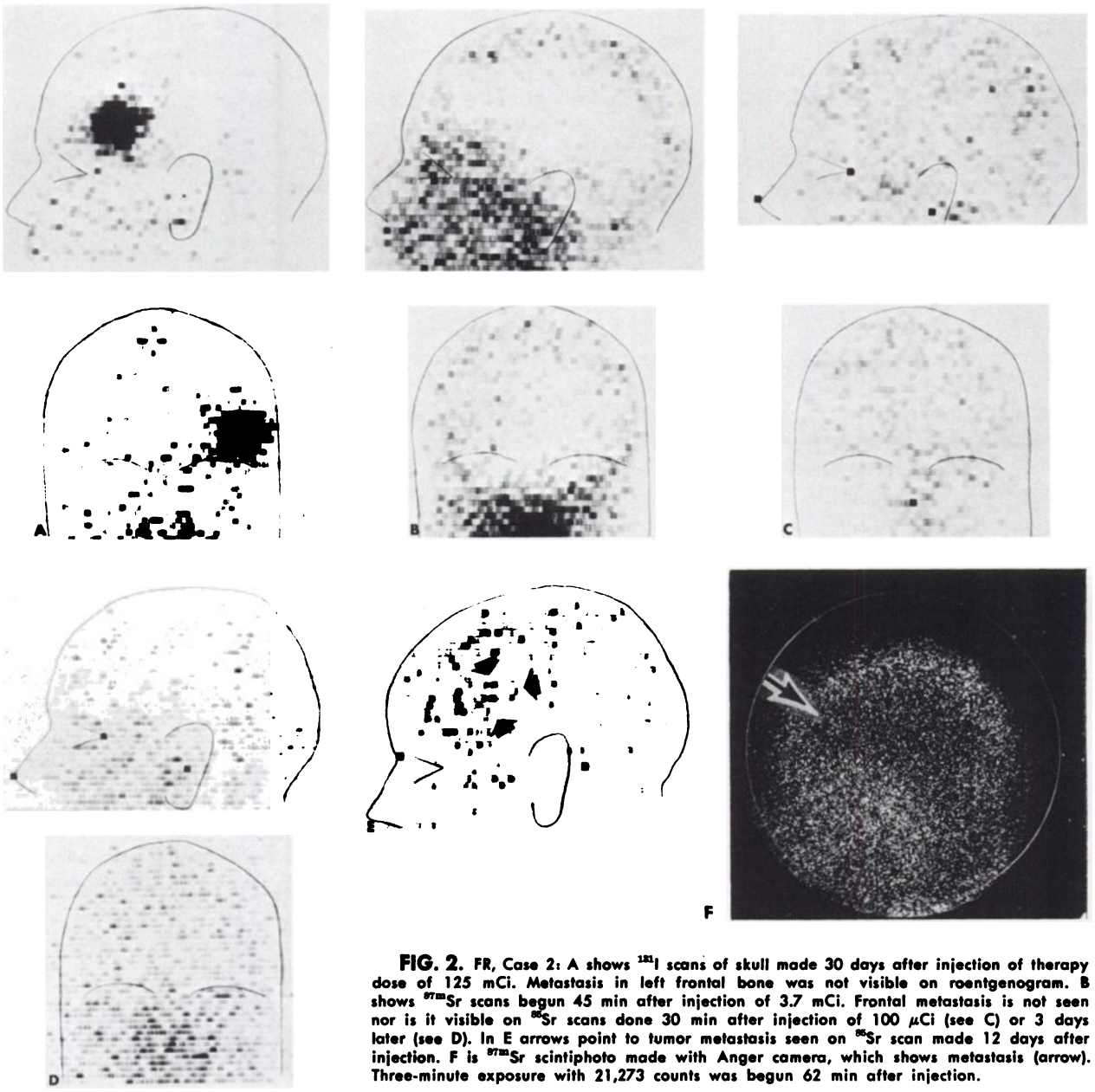

FIG. 2. FR, Case 2: A shows ^{131}I scans of skull made 30 days after injection of therapy dose of 125 mCi. Metastasis in left frontal bone was not visible on roentgenogram. B shows ^{87m}Sr scans begun 45 min after injection of 3.7 mCi. Frontal metastasis is not seen nor is it visible on ^{85}Sr scans done 30 min after injection of 100 μCi (see C) or 3 days later (see D). In E arrows point to tumor metastasis seen on ^{85}Sr scan made 12 days after injection. F is ^{87m}Sr scintiphoto made with Anger camera, which shows metastasis (arrow). Three-minute exposure with 21,273 counts was begun 62 min after injection.

punched-out lesions characteristic of myeloma and widespread severe demineralization. A pathologic supracondylar fracture of the left femur occurred in December 1966 which was treated with 2-MeV Roentgen rays from a Van De Graff generator over a 3-week period for total dose of 3,600 rads. When the patient was seen in March 1967, the entire left thigh was warm to the touch. A ^{87m}Sr scan of the lower extremities, begun 40 min after intravenous injection of 3.16 mCi, revealed considerable uptake in the left thigh which was wider than the diameter of either femur in addition to the abnormal uptake at the fracture site. A ^{85}Sr scan begun 2½ hr after injection was similar except for a lower counting rate, but a repeat scan made 3 days after the ^{85}Sr injection failed to show any disparity at all between the two thighs.

False-negative. Case 2 (Figs. 2 and 3). FR, a 53-year-old housewife, was found to have widespread, functioning metastases to lung and bone from a follicular carcinoma of the thyroid gland. Marked uptake of radioiodine was found in the left frontal bone but a ^{87m}Sr scan of the same region was not remarkable. A ^{85}Sr scan begun 30 min after intravenous injection and a 3-day postdose scan were similar to the ^{87m}Sr scan, but abnormal radiostrontium deposition was seen on scans made 6–12 days later. Epicranial counts showed no change in the

left-to-right ratio over a 6-day period, indicating that the change in the scintigram findings resulted from a generalized fall in background levels and not from a selective and progressive increase in isotope deposition. The lesion was later visualized on a ^{87m}Sr scintiphoto made with the Anger camera (Pho/Gamma, Nuclear-Chicago).

DISCUSSION

Because of the high body background shortly after injection of ^{87m}Sr, areas of abnormally increased vascularity will be visible on scans made with this isotope which could lead to an erroneous (false-positive) diagnosis of new bone formation whereas in fact no such situation exists. Casual inspection of the scan in Case I might suggest widespread reactive involvement of the femur with myeloma, but the clinical history of recent pathologic fracture treated by Roentgen rays and a warm leg indicate that abnormal blood flow and not new bone formation was the cause of the increase in radiostrontium counts. Superimposition of the scan on the roentgenogram clearly demonstrated that the excessive width of the left thigh on the scintigram was due to extraosseous counts. When blood and ECF levels of isotope fell several days after administration of ^{85}Sr, both thighs then had the same appearance on the scintigram. Thus the clinical and scintigraphic evidence indicate that abnormally increased blood flow to an area may result in a false-positive ^{87m}Sr scan. Since identical scan findings were obtained 2½ hr after injection of ^{85}Sr, it is clear that the abnormality is not related to a specific isotope of strontium but is characteristic of strontium scans in general.

The high blood and ECF counting rate shortly after ^{87m}Sr injection may result in visualization of nonosseous tumors (*4,5*). In our experience this has proved to be a source of confusion in evaluating some cranial lesions because it may not be clear from the ^{87m}Sr scan whether one is dealing with an intracerebral tumor or a metastasis to the cranial vault. Tow and Wagner have used ^{99m}Tc-pertechnetate to differentiate between these possibilities since the tumor-to-background ratio is higher with pertechnetate whereas the bone-to-background ratio is higher with ^{87m}Sr. This approach may not hold, however, in certain lesions such as meningiomas where bony involvement may accompany the soft-tissue lesion. We have found that in such cases it is preferable to rescan the patient several days after injection of ^{85}Sr; an abnormal scan invariably means bony invasion (*6*).

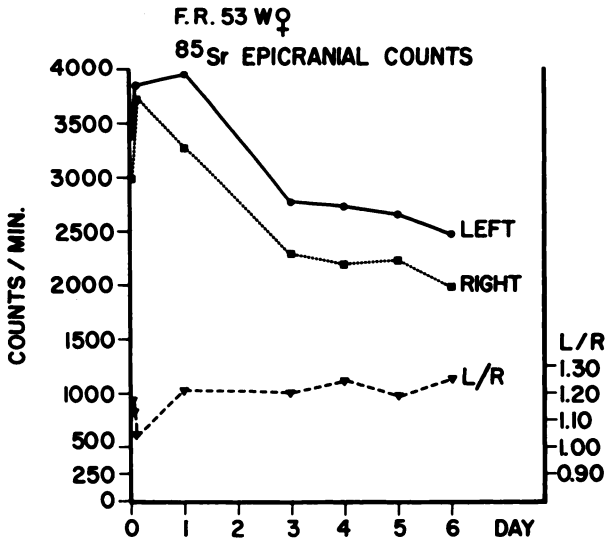

FIG. 3. FR, Case 2: Shows counting rate over frontal metastasis (left) after ^{85}Sr injection compared with normal (right) side. Although epitumor counts were 20% greater than over normal bone, lesion was not visible on rectilinear scans until Day 6.

Although Charkes, Sklaroff and Bierly stated that scans made with ^{87m}Sr and ^{85}Sr in six patients were identical, review of their data shows that in one patient (Case 16) the abnormality on the ^{87m}Sr scan somewhat exceeded the area of uptake noted on the ^{85}Sr scan and in the pathologic specimen. That patient also had a warm knee secondary to an osteogenic sarcoma of the tibia, and at first was thought to have osteomyelitis. In retrospect, the slight increase in the extent of the abnormality on the ^{87m}Sr scan in comparison with the ^{85}Sr scan is entirely similar to the changes noted above in Case 1 and most likely is the result of increased blood flow surrounding the affected bone.

False-negative ^{87m}Sr scans are of two types, one of which is related to the mechanism involved in false-positive scans. In this variety, illustrated by Case 2, information is buried in the high background counting rate and may become apparent only (1) when blood and ECF levels of the isotope have dropped; (2) if a sufficiently high initial counting rate is obtained, as with a digital scan or a fixed camera; or (3) by data processing of the scan information by closed-circuit television (*7*) or computer analysis. In Case 2 the lesion was visualized with the Anger camera but not with a rectilinear scanner.

The second type of false-negative scan occurs when there is progressive accumulation of ^{85}Sr in a metastatic lesion with time (*8,9*). In such cases, scans performed days or weeks after injection will show the lesion much better than did the initial scan.

This possibility was ruled out in Case 2 because the ratio of the epitumor counts to counts over a symmetrical normal bone remained steady over a 6-day period (Fig. 3) although the scan became positive.

Despite the drawbacks of ^{85}Sr as a bone-scanning agent (*10*), this isotope can produce scans free from the possible false-positive and false-negative defects inherent in the use of ^{87m}Sr. There will therefore always be a place for ^{85}Sr in clinical bone-scanning practice even though increased use of fixed cameras will increase the need for and the use of short-lived radionuclides such as ^{87m}Sr.

Both the false-positive and false-negative scans made with ^{87m}Sr which result in high nonosseous background levels of isotope are disadvantages which might not occur with ^{18}F (half-life 110 min) since unfixed ^{18}F is rapidly excreted into the urine shortly after injection (*11*). However, strontium-87m is currently preferred to ^{18}F for bone scanning because of its ready availability in generator form.

SUMMARY

Bone scans made with ^{87m}Sr are not always identical to those made with ^{85}Sr. Areas of increased blood flow may simulate bone tumors on ^{87m}Sr scans (false-positive scan) and known bone tumors may be buried in the high body background shortly after isotope administration, giving rise to false-negative scans. These points are brought out by two cases. The ^{85}Sr scan performed 48 hr after injection is not subject to these interpretive errors and may also become more positive with time as a result of progressive increment in strontium deposition.

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