A Study of ^{99m}Tc-Polyphosphate as a Joint Imaging Agent

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SUMMARY

This study shows an example of the pronounced uptake of ^{99m}Tc-polyphosphate in the hand joints of a patient with rheumatoid arthritis. Bone-labelling and blood-labelling radio-isotopes, ^{18}F and ^{113m}In respectively, have been used to help establish, image-wise, the site of uptake in the joints. A comparison of the joint uptake of ^{99m}Tc-polyphosphate with that of ^{99m}Tc has also been made, and shows that ^{99m}Tc-polyphosphate is superior in this aspect.

The use of ^{99m}Tc-polyphosphate as a joint agent is suggested.

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The first metabolisable complex of ^{99m}Tc, using tripolyphosphate and stannous chloride, was formulated by Subramanian and McAfee,[1] and it was suggested that this radiopharmaceutical agent might be suitable for skeletal imaging. In their paper the preparation of this complex was described, together with experiments performed on the organ distribution of the preparation in adult albino rabbits. The results of the simultaneous distribution studies of ^{99m}Tc-pertechnetate tripolyphosphate (^{99m}Tc-STPP) and ^{85}Sr indicated that 37 - 45% of the radioactivity of administered ^{99m}Tc was localised in the skeleton, and that the average skeletal concentration of ^{99m}Tc-STPP ranged from 46% to 68% of the ^{85}Sr concentration between 1 and 24 hours. However, the activity of ^{99m}Tc-STPP in the blood was high compared with that of ^{85}Sr, because of the poor excretion of this complex, which is a distinct disadvantage in a skeletal imaging radiopharmaceutical agent.

A further paper by Subramanian and McAfee[2] reported the preparation of a synthetic linear long-chain polyphosphate (POLYP) having a higher molecular weight than the tripolyphosphate, and which cleared more rapidly from the blood. In fact, the blood levels with this new version were comparable with those with ^{85}Sr up to 3 hours after injection.

This complex was then used for skeletal imaging in humans, with very good results. ^{99m}Tc-POLYP is now commercially available and a dose of 10 mCi/70 kg body weight is administered as a routine, which gives a skeletal absorbed radiation dose of 0,45 rads.

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METHODS

Observations

We decided to try ^{99m}Tc-POLYP as a skeletal imaging radiopharmaceutical, and observed that with one patient, in whom particular views of the arms and hands were required for a neurological investigation, good concentration of the radiopharmaceutical occurred in the hands (Fig. 1).

It was thought that ^{99m}Tc-POLYP could perhaps be used as a joint imaging agent. Other workers[3] have used ^{99m}Tc-pertechnetate and scintigraphy as a valuable adjunct in the treatment of arthritic disease, and they showed that the uptake of this radio-isotope in arthritic joints often indicates the subclinical presence of the disease.

Further Investigations

A Nuclear Chicago Pho Gamma III gamma camera was used throughout the investigations, with the single pinhole collimator attached for close-up views of the hands. A patient with clinically active rheumatoid arthritis was examined for hand joint uptake of ^{99m}Tc-POLYP. The X-ray films (Fig. 2 and enlarged Fig. 10) show porotic bones with marked erosions of the metacarpophalangeal and, to a lesser degree, of the carpal joints, with subluxation of the third metacarpophalangeal joint. Osteo-arthritic changes are present in the interphalangeal joints and there is an old fracture of the ulnar styloid. The corresponding scintigram (Fig. 3) shows enhanced uptake in all the metacarpophalangeal joints except the fourth, which radiologically also does not appear to be as involved as the others. No abnormal uptake appears in the osteo-arthritic interphalangeal joints, and uptake is only minimally enhanced in the carpal joints. Again, one must postulate that the disease process is not as advanced in the carpal joints. Maximum activity appears in the third metacarpophalangeal joint, as expected.

Simple digital processing of a scintigram (Fig. 4) taken at a closer hand-to-collimator distance of the same patient, gave a source/background count ratio of 2,1 : 1 over the third joint, with only 25 k counts accumulated in a very convenient time of 5 min. The background count was selected from the lowest count areas in the hand, between the knuckle joints and the wrists.

A comparison of the joint uptake in the rheumatoid arthritis case was made with that in a normal subject. A 30-year-old female with clinically normal hands underwent skeletal scanning with ^{99m}Tc-POLYP. Scintigrams

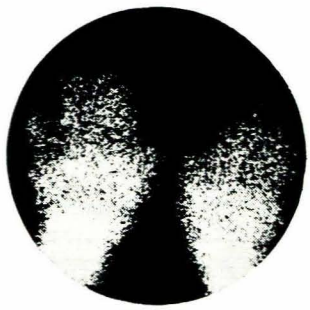

Fig. 1

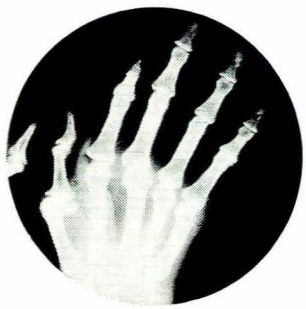

Fig. 2

Fig. 3

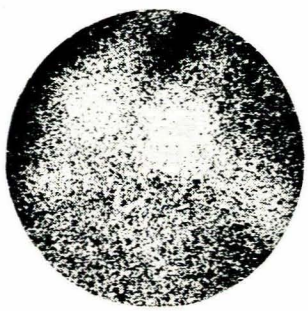

Fig. 4

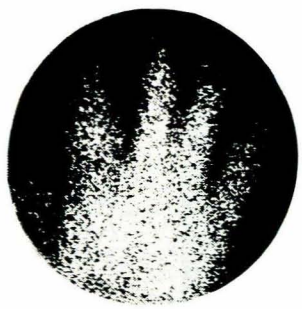

Fig. 5

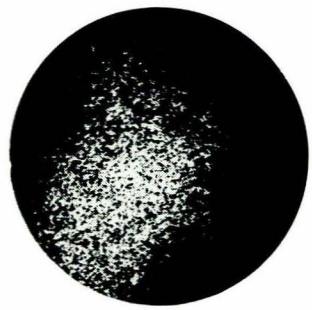

Fig. 6

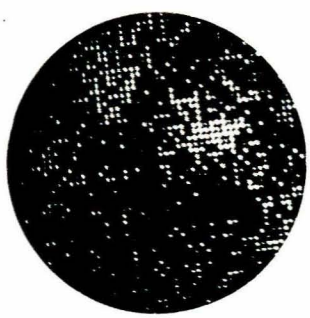

Fig. 7

Fig. 8

Fig. 9

Fig. 1. ^{99m}Tc-POLYP scintigram of the hands of a patient with neurological disease.
Fig. 2. Radiograph of the right hand of the patient with rheumatoid arthritic hands.
Fig. 3. Scintigram of the right hand of patient immediately after injection.
Fig. 4. Close-up scintigram of the third metacarpophalangeal joint of the right hand of the rheumatoid arthritic patient.
Fig. 5. Scintigram of the right hand of the 30-year-old control subject immediately after injection.
Fig. 6. ^{18}F scintigram of the right hand of patient.
Fig. 7. Digitised subtraction scintigram showing areas of ^{99m}Tc-POLYP uptake with blood background subtracted.
Fig. 8. ^{99m}Tc-pertechnetate scintigram of right hand 30 min after injection.
Fig. 9. ^{99m}Tc-pertechnetate close-up scintigram of the third metacarpophalangeal joint.

were taken of her right hand immediately after injection of the radiopharmaceutical (Fig. 5). This scintigram contrasts markedly with the previous one (Fig. 3), in that very little definitive joint uptake can be seen.

It was important to establish whether this increased uptake of ^{99m}Tc-POLYP was owing to increased bone metabolism of the joint or to increased vascularity of the joint, and whether ^{99m}Tc-pertechnetate or ^{99m}Tc-POLYP was responsible.

A ^{18}F bone scintigram (Fig. 6) shows no evidence of increased bone metabolism in the joints. Vascularity of the hand was visualised by using ^{113m}In. The resulting

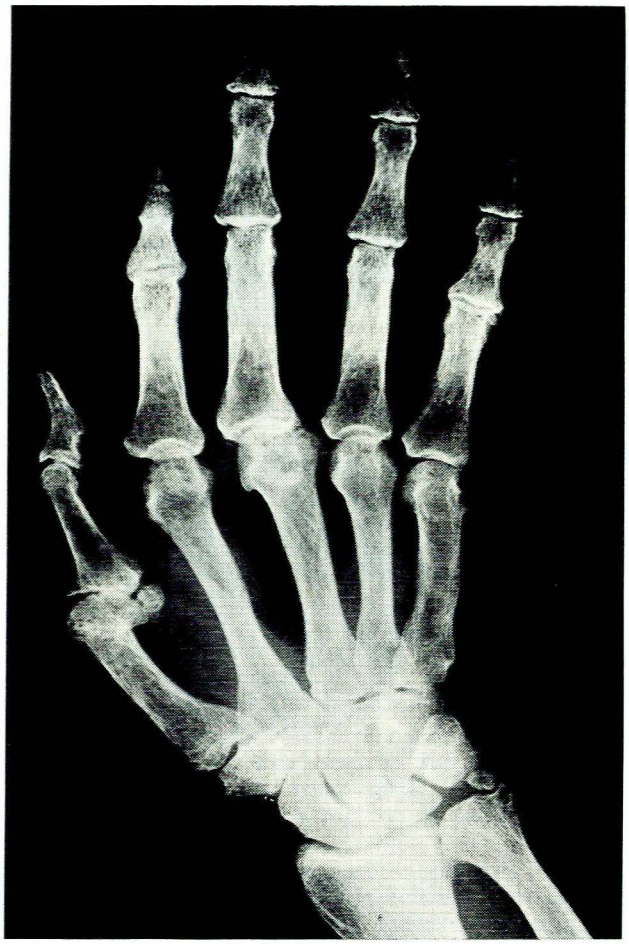

Fig. 10. Enlargement of radiograph in Fig. 2.

scintigram image was subtracted from the ^{99m}Tc-POLYP image, and the final image (Fig. 7) showed that the abnormal joint uptake was not caused by increased vascularity of the joints. Finally, ^{99m}Tc-pertechnetate joint scintigrams performed 30 - 40 min after injection, the time of maximum uptake, show a slightly increased uptake in the third joint (Fig. 8). The other joints in the hand, in which rheumatoid arthritis was not so severe, failed to show up on the ^{99m}Tc scintigram.

A further scintigram, taken at a closer hand-to-collimator distance (Fig. 9), gave a source/background ratio of 1,3:1, which indicates a much lower uptake of ^{99m}Tc-pertechnetate compared with ^{99m}Tc-POLYP.

CONCLUSION

The observations described in this article seem to suggest a preferential uptake of ^{99m}Tc-POLYP in joints. The uptake is obviously related to the degree of vascularity of the synovial membrane, hence the marked increased uptake in certain joints of the patient suffering from rheumatoid arthritis. It has been shown by other workers[4] that uptake of ^{99m}Tc in the synovial membrane does not occur, and that only minimal radioactivity is present in the synovial fluid. *In vitro* and further clinical work is in progress to try to establish whether this suggested joint uptake of ^{99m}Tc-POLYP occurs in the synovial membrane or in the joint fluids.

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