Fluorine 18
(^{18}F) as Fluoride Ion in Saline Solution
Package Insert Information

Description

This solution contains no-carrier-added fluorine-18 as the fluoride ion in isotonic sodium chloride solution. The ^{18}F is produced by bombardment of neon gas by deuterium particles accelerated in a cyclotron. The nuclear reaction is $^{20}Ne(d, \alpha)\ ^{18}F$. The product is essentially carrier free; the only known source of nonradioactive fluoride ion present is that found in the distilled water and saline solutions used in preparing this product.

Actions (Clinical Pharmacology)

Following its intravenous administration ^{18}F fluoride rapidly equilibrates, primarily within the extracellular fluid space, from where it is rapidly cleared by deposition in bone and excretion into urine. Deposition of ^{18}F fluoride in bone appears to be primarily a function of blood flow to the bone and the efficiency of the bone in extracting the ^{18}F from the blood perfusing the bone.[1]

Fluoride ions do not appear to be bound to serum proteins, and the clearance of ^{18}F from the blood is rapid.[2]

In patients with normal renal function, 20% or more of the ^{18}F is cleared from the body in the urine within the first two hours after its intravenous administration.[3] Subsequently, small amounts of ^{18}F continue to be excreted in the urine further diminishing ^{18}F activity in soft tissues of the body.

^{18}F normally accumulates in the skeleton in a symmetrical fashion, and with greater deposition in the axial skeleton (e.g., vertebrae and pelvis) than in the appendicular skeleton and in the bones around joints than in the shafts of long bones. Increased deposition around joints can occur in arthritis and following trauma and increased deposition in bone has been noted around fracture sites, in osteomyelitis, fibrous dysplasia, spondylitis tuberculosa, Paget's disease, hyperstosis frontalis interna, myositis ossificans and in rapidly growing epiphyses. The tendency for ^{18}F to accumulate in the vicinity of primary and metastatic malignancy in bone has proven clinically useful in detection of such lesions.[3-10]

Indications

^{18}F is used as a bone imaging agent to define areas of altered osteogenic activity.

Contraindications

None.

Warnings

^{18}F should not be administered to pregnant women, those liable to be pregnant, in lactation, or in patients under 18 years of age unless the benefits to be gained outweigh the risks. Radiopharmaceuticals produced in a nuclear reactor or particle accelerator should be used only by physicians who are qualified by specific training in the safe use in handling of radioisotopes and whose experience and training has been approved by the appropriate governmental agency authorized to license the use of radionuclides.

Precautions

The patient should be encouraged to drink fluids immediately before and following administration of the ^{18}F preparation. To minimize radiation dose to the bladder, the patient should void one-half hour after administration of the ^{18}F and as often thereafter as is possible. Voiding immediately prior to imaging ^{18}F distribution in the pelvis is recommended. In the use of any radiopharmaceutical care should be taken to insure minimum radiation exposure to patient and all personnel involved in the procedure by using the smallest dose of radioactivity consistent with safety and relative value of diagnostic information.

Adverse Reactions

No adverse reactions were noted in over 400 patient studies reported in the medical literature.

Dosage

The dose of ^{18}F used in a given patient should be minimized consistent with the objectives of the study, and the nature of the radiation detection devices employed. Satisfactory studies have been reported following administration of between 0.5 and 2.0 mCi of ^{18}F activity administered intravenously. However, it has been estimated that use of even 4.0 mCi of ^{18}F results in a calculated whole body radiation dose one-sixth of that associated with the use of approximately 100 μCi of ^{85}Sr. It is recommended that the dose of ^{18}F used in a given study not exceed 4 mCi. The patient should be instructed to ingest copious amounts of fluid immediately prior and subsequent to the administration of ^{18}F. The patient should void one-half hour after administration of ^{18}F and as frequently thereafter as possible. Imaging of the ^{18}F can begin one to two hours after administration of the ^{18}F, however, the longer the imaging procedure is delayed, the greater will be the ratio of activity in bone to that in soft tissue. The patient should be instructed to void immediately prior to imaging the ^{18}F activity in the lumbar spine or bony pelvis.

In the past, ^{18}F has been most commonly administered intravenously. However, some investigators have reported satisfactory results following oral administration.

Dosimetry

^{18}F decays with a physical half-life of 109.7 minutes (1.828 hrs.). 97% of the decay results in emission of a positron with a maximum energy of 0.635 MeV and 3% of the decay results in electron capture with subsequent emission of characteristic X-rays of oxygen. The bone and bone marrow are considered the target and critical organs and the absorbed radiation dose to these organs and the whole body can be calculated using the absorbed fraction method using the following equation:

$$\bar{D}\,(v \leftarrow v) = \frac{\tilde{A}_v}{m_v} \sum_i D_i \phi_i\,(v \leftarrow v)$$

For the skeleton absorbed radiation dose may be calculated assuming uniform distribution of activity within the skeleton, that the skeleton is a 7000 gram ellipsoid and that 100% of administered radioactivity is retained in this organ. For gamma rays $\Delta_i = (2.13)\,(1.94)\,(0.511) =$

$2.11\ \frac{\text{gram-rad}}{\mu\text{Ci-hrs.}}$

$\phi_i = 0.130$ (assuming 5% backscatter)

$\tilde{A}_v = 10.56 \times 10^3\ \mu$Ci-hr. (for 4 mCi)

$$D_\gamma(v \leftarrow v) = \left(\frac{10.56 \times 10^3\ \mu\text{Ci-hr}}{7000\ \text{gram}}\right)\left(0.274\ \frac{\text{gram-rad}}{\mu\text{Ci-hr.}}\right)$$

$D_\gamma(v \leftarrow v) = 0.41$ rad to skeleton

For positrons, $\Delta_i = 2.13\,(0.97)\,(0.250) = 0.517\ \frac{\text{gram-rad}}{\mu\text{Ci-hr.}}$

$\phi_i = 1$ and $\Delta_i\phi_i = 0.517\ \frac{\text{gram-rad}}{\mu\text{Ci-hr.}}$

(since w_k and w_L are very small, K-radiation, L-radiation and Auger electrons from L and M shells are negligible).

$$\bar{D}_\beta\,(v \leftarrow v) = \left(\frac{10.56 \times 10^3}{7000}\right)(0.517)$$

$$= 0.79 \text{ rad to skeleton}$$

$\bar{D}_{\beta+\gamma}$ (skeleton $= 0.41 + 0.79 = 1.20$ rads for 4 mCi of ^{18}F.

Assuming 100% retention and uniform distribution of activity in the whole body (assuming whole body is a 70,000 gram ellipsoid) the whole body radiation dose from 4 mCi of ^{18}F can be calculated as follows:

For gamma rays:

$$\Delta_i\phi_i = (2.11)\,(0.341) = 0.720\ \frac{\text{gram-rad}}{\mu\text{Ci-hr}}$$

$$\bar{D}_\gamma(v \leftarrow v) = \left(\frac{10.56 \times 10^3}{70{,}000}\right)(0.720) = 0.11 \text{ rads}$$

$$\bar{D}_\beta(v \leftarrow v) = \left(\frac{10.56 \times 10^3}{70{,}000}\right)(0.517) = 0.08 \text{ rads}$$

$\bar{D}_{\beta+\gamma}$ (whole body) $= 0.11 + 0.08 = 0.19$ rads for 4 mCi of ^{18}F.

How Supplied

^{18}F as the fluoride ion in isotonic saline solution at ph 6-8, prepared by appropriate manufacturing procedures to be sterile and pyrogen free.

Calibration Chart

Time	Specific Concentration of ^{18}F (mCi/ml)
2 hours before calibration	4.20
1½ hours before calibration	3.49
1 hour before calibration	2.90
½ hour before calibration	2.41
Calibration Time	2.00
½ hour after calibration	1.66
1 hour after calibration	1.38
1½ hours after calibration	1.15
2 hours after calibration	.95
2½ hours after calibration	.79
3 hours after calibration	.66
3½ hours after calibration	.55
4 hours after calibration	.45
4½ hours after calibration	.38
5 hours after calibration	.31
5½ hours after calibration	.26
6 hours after calibration	.22

References

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medi+physics

5855 Christie Avenue
Emeryville
California 94106

900 Durham Road
South Plainfield,
New Jersey 07080