mird / DOSE ESTIMATE REPORT NO. 3

# SUMMARY OF CURRENT RADIATION DOSE ESTIMATES TO HUMANS WITH VARIOUS LIVER CONDITIONS FROM $^{99m}$Tc-SULFUR COLLOID

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**SUMMARY OF ESTIMATED ABSORBED DOSES PER mCi OF $^{99m}$Tc FOR VARIOUS LIVER CONDITIONS FROM A SINGLE INTRAVENOUS ADMINISTRATION OF $^{99m}$Tc-SULFUR COLLOID**

| | Absorbed dose rads/mCi of $^{99m}$Tc injected | | |
|---|---|---|---|
| Tissue | Normal liver | Early-to-intermediate diffuse parenchymal liver disease | Intermediate-to-advanced diffuse parenchymal liver disease |
| Liver | 0.34 | 0.21 | 0.16 |
| Ovaries | 0.0056 | 0.0081 | 0.012 |
| Red marrow | 0.027 | 0.045 | 0.079 |
| Spleen | 0.21 | 0.28 | 0.42 |
| Testes | 0.0011 | 0.0021 | 0.0032 |
| Total body* | 0.019 | 0.019 | 0.018 |

* Includes dose from source organs plus dose from $^{99m}$Tc assumed to be distributed uniformly in the total body.

## RADIOPHARMACEUTICAL

This dose estimate report is applicable to $^{99m}$Tc-sulfur colloid prepared either commercially or in the nuclear medicine laboratory from commercial kits for routine clinical studies. For purposes of these dose calculations the radiochemical purity of the pharmaceutical was assumed to be 97% and the radionuclidic purity 100%.

## NUCLEAR DATA

Nuclear data for $^{99m}$Tc are given in Table 1.

**TABLE 1. NUCLEAR DATA***

| | | |
|---|---|---|
| Radionuclide | $^{99m}$Tc (1) | |
| Physical half-life | 6.03 hours | |
| Decay constant | 0.1149 hours$^{-1}$ | |
| Mode of decay | Isomeric level | |
| Equilibrium dose constant for nonpenetrating radiation (g-rad/$\mu$Ci-h) | 0.0369 | |
| | $E_i$ (MeV) | $n_i$ |
| Principal photons: | 0.0186‡ | 0.077 |
| $E_i$, energy | 0.1405 | 0.879 |
| $n_i$, mean number/dis† | | |

* For complete compilation of nuclear data, the reader is referred to Ref. 1. Values computed by L. T. Dillman using method described in Ref. 1.

† Photons whose mean number per disintegration is 0.01 or greater.

‡ Weighted mean energy of K x-rays.

## BIOLOGIC DATA

No retention, excretion, or tissue data from humans were available to the Committee for this radiopharmaceutical. For this reason, estimates were solicited for the percentage localization of $^{99m}$Tc after a single intravenous injection of $^{99m}$Tc-sulfur colloid to normal patients and to those with either early-to-intermediate or intermediate-to-advanced diffuse parenchymal liver disease. Responses were received from 9 of the 14 nuclear medicine laboratories contacted. The sites of $^{99m}$Tc localization were assumed to be liver, spleen, red marrow, and rest of body (Table 2). It was also assumed that no $^{99m}$Tc was excreted from the body. These laboratories also provided estimates for the mass of the liver, spleen, and red marrow for the two abnormal liver conditions given in Table 3, as classified by J. G. McAfee from data in Refs. *2–5*.

Early-to-intermediate diffuse parenchymal liver disease includes patients who may or may not be symptomatic but who usually have hepatomegaly and frequently splenomegaly. The biochemical tests may either be normal or show an increase in serum globulins, serum transaminase, impaired BSP excretion, and increased urobilinogen in the urine.

Intermediate-to-advanced diffuse parenchymal liver disease refers to jaundiced patients who may have ascites associated with generalized symptoms

**TABLE 2. TISSUE DISTRIBUTION FOR $^{99m}$Tc FROM SULFUR COLLOID**

| | Percent of injected $^{99m}$Tc per organ | | | |
|---|---|---|---|---|
| Liver condition* | Liver | Spleen | Red marrow | Other† |
| Normal | 85 | 7 | 5 | 3 |
| Early-to-intermediate diffuse parenchymal liver disease | 67 | 13 | 12 | 8 |
| Intermediate-to-advanced diffuse parenchymal liver disease | 32 | 30 | 25 | 13 |

* Classification developed by J. G. McAfee from data in Refs. 2-5.

† Three percent is assumed to be in noncolloid form and the remainder taken up by macrophages in the lung and elsewhere. For dose calculations, this activity is assumed to be uniformly distributed in the mass of the total body less the mass of liver, spleen, and red marrow and has an effective half-life equal to the physical half-life of $^{99m}$Tc.

**TABLE 3. LIVER, SPLEEN, AND RED MARROW MASS FOR VARIOUS LIVER CONDITIONS**

| Liver condition | Organ weight (grams) | | |
|---|---|---|---|
| | Liver | Spleen | Red marrow |
| Normal* | 1,809 | 174 | 1,500 |
| Early-to-intermediate diffuse parenchymal liver disease | 2,400 | 250 | 1,500 |
| Intermediate-to-advanced diffuse parenchymal liver disease | 1,400 | 400 | 1,500 |

* Organ weights for the anthropomorphic model used to estimate the dose for the normal liver condition (7).

of weakness, emaciation, and frequently fever. The biochemical tests would indicate elevated serum globulins, urinary urobilinogen, serum alkaline phosphatase and transaminase, impaired BSP excretion, and elevated serum bilirubin.

## ABSORBED-DOSE ESTIMATES

The cumulated activity in the four source regions for the three liver conditions was computed assuming instantaneous uptake and uniform distribution of the activity in the source regions. The effective half-life is assumed to be equal to the physical half-life of $^{99m}$Tc. The distribution data are given in Table 2.

The absorbed fractions used for the dose estimate calulations in this report were obtained from special Monte Carlo computer calculations using the complete energy spectrum of penetrating and nonpenetrating radiations emitted by $^{99m}$Tc instead of from the interpolated values of absorbed fractions published in MIRD Pamphlet No. 5 (6). The heterogeneous phantom (7) used for these calculations is a modification of that described in MIRD Pamphlet No. 5 and more nearly simulates man. The red marrow is considered as a separate source organ in the modified phantom.

Calculation of the radiation doses for the two pathologic conditions required modification of the phantom model to account for the changes in mass of the liver and spleen. The liver is defined by a right elliptical cylinder cut by a plane that corresponds approximately to the visceral surface of the liver (6). For the pathologic liver conditions, the increase in the liver mass is obtained by moving the plane that cuts the cylinder toward the spleen, and the decrease in the liver mass is obtained by moving the plane away from the spleen. The spleen is defined by an ellipsoid (6). For the pathologic liver conditions, the increase in splenic mass is obtained by increasing the dimensions of the axes of the ellipsoid by a constant factor.

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