General Nuclear Medicine

Generators:

Molybdenum-Technetium generators provide an example of "**transient equilibrium**" which is seen when the half-life of the parent nuclide is moderately longer than that of the daughter. If the generator is left untouched an equilibrium occurs between the rate of Mo-99 decay (and therefore the rate of Tc-99m accumulation) and the rate of Tc-99m decay. It takes about 4 daughter half-lives to reach equilibrium. When the equilibrium is reached, the amount of Tc-99m available is approximately equal to the amount of Mo-99 present and the entire system decays with an effective half-life of Mo-99. (The Tc-99m radioactivity decays with an apparent half-life of the parent radionuclide Mo-99). The actual amount of Tc-99m available is slightly less than the Mo-99 activity due to about 10% of Mo-99 decaying directly to Tc-99.

The column within the generator is made of alumina (Al2O3) and Mo-99 is adherent to this column. Saline elutes Tc-99m in the form of sodium pertechnetate (NaTc-99m04) from the column, while Mo-99 remains attached to it. Following elution the Tc-99m activity quickly reaccumulates, reaching a maximum in about 23 hours. About 50% of this peak activity is reached within 8 hours, so it is feasible to elute the generator every few hours if necessary.

Radiopharmaceutical Quality Control:

QC of the radiopharmaceutical can be separated into categories of sterility, chemical purity, radionuclide purity, and radiochemical purity.

Chemical Purity

Aluminum (Al^{+3}) is a chemical contaminant which can found in the Technetium eluate, but this is rarely a problem with modern day generators. Aluminum can interfere with some labeling reactions. The United States Pharmacopeia (USP) limits the amount of aluminum which can be detected in the eluate to less than 10 ug/ml.

Radionuclide Purity

Molybdenum is the most important radionuclide contaminant. Each time a generator is eluted it must be evaluated for Mo-99 breakthrough. When given intravenously molybdate is phagocytized by the reticuloendothelial system. Its long half life and beta emissions result in a very high radiation dose even from only a small amount of activity. Current regulations limit Mo-99 activity to 0.15uCi/mCi of Tc-99m at the time of administration (0.15kBq/1MBq). Mo-99 can be produced by fission of U-235 in a reactor, or by irradiation of Mo-98 with neutrons. Mo-99 produced in fission reactions is essentially carrier free. However, other radionuclide contaminants such as I-131, Ru-103, Sr-89, and Sr-90 may be detected. The USP sets limits for these contaminants as well. Less common contaminants which are rarely of clinical relevance include Nb-92, Nb-95, and Zr-95. In the Mo-99 produced by neutron irradiation, the most common impurities are Cs-134, Co-60, Rb-86, and Sb-124.

Radiochemical Purity

Radiochemical impurities are Tc-99m compounds other than the desired radiopharmaceutical. There is always some unlabeled Tc-pertechnetate, as well as insoluble technetium colloids. Reduced technetium can be hydrolyzed to Tc02 or can complex with tin colloids. These stannous or technetium colloids localize to the reticuloendothelial system.