Particle Reduction of a Macroaggregated Albumin Kit: Simplified Calculations

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It is often difficult to compound a dose of technetium-99m (^{99m}Tc) macroaggregated albumin, which contains both a specified number of particles, as well as a specific dose in millicuries. This is further complicated by the fact that the commercial kit used contains many times more particles than is needed, particularly in the pediatric patient population. We have developed a set of simple formulas to facilitate calculating the number of millicuries and volume of sodium pertechnetate (^{99m}Tc) to be added to the kit.

PARTICLE REDUCTION

The performance of pulmonary perfusion studies using technetium macroaggregated albumin (^{99m}Tc-MAA) presents special problems in the neonate and child under the age of three, since the pulmonary vasculature is immature, and the number of alveoli is considerably fewer than in the adult. It is estimated that the lung contains 20×10^6 alveoli at birth, 257×10^6 alveoli by age four, and up to 600×10^6 alveoli in the normal adult (*1,2*). Since the ^{99m}Tc-MAA particles localize by embolization in the capillaries of the lung, there is in theory a need to minimize the number of particles injected into an individual with a relatively small number of capillaries (*3–4*).

There is further concern for the safety of a young child with a right-to-left cardiac shunt. In this case, a portion of the injected particles bypasses the lungs and enters the systemic circulation (*4*). A minimal number of particles/dose is required to prevent microembolization of the cerebral and renal capillaries. When a shunt study only, with no lung image, is required, as little as 10,000 particles may be used with minimal systemic embolization (*5*).

To determine the dose of technetium to be given, one needs to consider both the calculated dose in millicuries as well as the prescribed number of particles. The calculations may be confusing. In this communication, we present our method for performing these calculations.

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MATERIAL AND METHOD

The following case will illustrate the calculations involved in reducing the number of particles given in a specific dose of ^{99m}Tc-MAA. An infant weighing 8 kg was sent to the nuclear medicine department for quantification of a right-to-left cardiac shunt. The physician has requested that the child should receive ~40,000 particles. The calculated dose based on the patient's weight is 0.5 mCi. Since excessive dilution of the stannous ion may result in a poor tag, the volume of the dose is limited to 0.1 ml.

A commercially available ^{99m}Tc albumin aggregate kit containing albumin aggregated 1 mg, albumin human 10 mg, total tin as ($SnCl2 \cdot 2H_20$) 0.12 mg, and ~5 million particles was used.

Calculations

1. To reduce the number of particles in the vial to 1 million in a volume of 1 ml, 5 ml sodium chloride injection USP was added to the kit. It was shaken gently to disperse the particles and 4 ml of solution was withdrawn and discarded.

2. In this calculation, we determined the volume of [^{99m}Tc] pertechnetate to add to the kit. For this example we will assume that the dose should contain 40,000 particles. This number can be increased or decreased, as needed, for the individual patient. We use the following proportional equation:

$$V_2 = \frac{V_1 P_1}{P_2},$$

where

- V_2 = final volume of solution in the kit
- V_1 = the desired volume, in milliliters
- P_1 = total number of particles in the vial (in this case it is 1,000,000)
- P_2 = the required number of particles in the individual dose (40,000 in our example)
- V_2 = 0.1 ml × 1,000,000/40,000 = 2.5 ml.

Since the vial already contains 1 ml from Step 1 the desired activity of sodium pertechnetate (^{99m}Tc) should be contained in 2.5 − 1 = 1.5 ml of solution.

3. To determine the total activity of sodium pertechnetate to add to the kit, use the following proportional equation:

$$M = \frac{DV_2}{V_1},$$

where

- M = the total number of millicuries of sodium pertechnetate (^{99m}Tc) to be added to the vial
- D = dose in millicuries of ^{99m}Tc-MAA to be given to the patient, based on the patient's weight in kg
- V_2 = volume in mls of total solution in the vial (2.5 ml in our example)
- V_1 = volume in milliliters of the dose (0.1 ml in this example).

Therefore in our example assuming a 0.5-mCi dose:

$$M = \frac{0.5 \text{ mCi} \times 2.5 \text{ ml}}{0.1 \text{ ml}} = 12.5 \text{ mCi}.$$

The mixture was allowed to incubate for at least 10 min. Chromatography was performed using acetone as the mobile phase to test for unbound sodium pertechnetate, prior to the administration of the dose to the patient. The kit should be 90% bound or greater. If this level of binding is not achieved, the kit is allowed to incubate 10 min longer, then the chromatography is repeated.

RESULTS

We have used our set of equations to compound ^{99m}Tc-MAA for eleven patients. One kit failed to meet our minimum criteria of 90% binding of the pertechnetate to the albumin aggregate after 45 min. A new kit was compounded and it was 92% bound. One kit required an additional 10-min incubation period to achieve 94% binding. The remaining nine kits were 91%–100% bound within 5 min. In another study of 10 patients in which the kit was made up in the traditional way (i.e., adding 100–250 mCi of pertechnetate to the kit and withdrawing the solution at 0–1 ml per dose) 90%–98% labeling was achieved with this method.

DISCUSSION AND CONCLUSION

When preparing a dose of ^{99m}Tc-MAA for neonates, young children, and patients with right-to-left cardiac shunts, both the number of millicuries administered as well as the number of particles must be kept to a minimum. A dose of ^{99m}Tc-MAA compounded in the method suggested in the manufacturer's package insert will yield a dose containing 400,000–2,000,000 particles for an adult. The neonate and shunt patient requires a ^{99m}Tc-MAA dose containing a reduced number of particles, usually 20,000–40,000. This particle reduction can be accomplished by greatly increasing the activity of [^{99m}Tc]pertechnetate added to the cold kit. The problem with this approach is that the volume of the dose will be too small for the syringes used. Our method of compounding ^{99m}Tc-MAA produces a kit of high specific activity, which then allows the dose to be drawn in a convenient volume. We have developed a set of proportional equations to facilitate the calculations. Any of the variables may be changed to accommodate the needs of a specific patient. We have used small volumes because we were concerned about diluting the stannous ion to a concentration where it could not achieve effective reduction of the pertechnetate ion. This would lead to a poor tag of pertechnetate to the albumin. We feel that a longer incubation period helps overcome this dilution effect.

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