Comparison of Technetium-99m MAG3™ and Iodine-131 OIH ERPF Results Using the Camera Technique

Alberto J. Arroyo

St. Vincent Medical Center, Toledo, Ohio

Recent studies have suggested that technetium-99m (^{99m}Tc) MAG3 can be substituted for iodine-131 (^{131}I) OIH, with better image quality and lower radiation dose. This study compares the two radiopharmaceuticals for effective renal plasma flow (ERPF) results using only the camera method. Twenty patients with varying degrees of renal impairment were studied. In 13 of these patients, direct comparisons were made between the two compounds. The latter group consisted of 7 females and 6 males, including 3 normals. Sequential serial digital 30-min ^{99m}Tc-MAG3 and [^{131}I]OIH imaging studies were performed. Renogram curves were generated and ERPF values calculated using Schlegel's program. By slight modification of the formula, the results obtained with ^{99m}Tc-MAG3 compared well with those obtained with [^{131}I]OIH ($p < 0.01$).

The high energy (364 KeV) of [^{131}I]OIH produces high radiation exposure for the patient. It also has clear disadvantages for routine clinical use due to its poor imaging properties. In contrast, images obtained with ^{99m}Tc-MAG3™ (Mallinckrodt Medical, Inc., St. Louis, MO) have consistently provided better structural kidney detail in patients with a wide range of serum creatinine levels (*1*) and in cases of severely impaired renal function (*2*). Previous articles have demonstrated that ^{99m}Tc-MAG3 has similar biological properties to [^{131}I]OIH in normal volunteers (*1,3,4*), patients with renal disease (*5*), and hemodialysis patients (*6*). When a proportionality constant in the single 44-min plasma sample calculation of ERPF with ^{99m}Tc-MAG3 was introduced, good agreement was found with those obtained using [^{131}I]OIH (*7*). This constant has varied from 0.56 to 0.67 (*1,3,5,7*).

There have been no published reports on the use of the U.S. kit formulation of ^{99m}Tc-MAG3 for the calculation of ERPF utilizing the gamma camera method. The purpose of this study is to compare ^{99m}Tc-MAG3 and [^{131}I]OIH ERPF results using only Schlegel's formula (*8*) and the camera (no blood sample), and to try to determine which proportionality constant gives the best results.

For reprints contact: Alberto Arroyo, 2213 Cherry Street, Toledo, Ohio 43608-2691.

MATERIALS AND METHODS

A large field of view camera, the Elscint 409 mobile (Elscint Inc., Hackensack, NJ), was fitted with a low energy medium resolution/medium sensitivity collimator for ^{99m}Tc imaging. Each patient was injected with 2–2.5 mCi ^{99m}Tc-MAG3. For [^{131}I]OIH, a medium energy high sensitivity collimator was used with a dose of 250–300 μCi. All patients received intravenous injections through a butterfly infusion set to avoid infiltration. Many patients have extremely small and fragile veins. Using a butterfly, we were able to ensure we were in the vein before injections were made. Both doses were counted for 1 min, in a special phantom holder at a distance of 30 cm from the collimator face, immediately prior to and following each patient study.

Each set of data was acquired in dynamic mode at 2 sec per frame for 120 sec, followed by 15 sec per frame for 28 min for ^{99m}Tc-MAG3 and 15 sec per frame for 30 min for [^{131}I]OIH. The digital images were reframed for data display and processing. Calculations of ERPF for each radiopharmaceutical were performed according to the current commercially available Schlegel's program (adapted for Elscint Inc., Hackensack, NJ). Different proportionality constants were tried in order to find the best regression equation and correlation coefficient for the ERPFs of the two radiopharmaceuticals.

RESULTS

The kidney curves for all patients were similar for both ^{99m}Tc-MAG3 and [^{131}I]OIH. The ^{99m}Tc-MAG3 curves were smoother and statistically better and the images were of far greater quality than those obtained with [^{131}I]OIH on patients whose degree of renal function varied widely; even for those whose blood urea nitrogen (BUN) and creatinine levels were as high as 87 mg/dl and 13 mg/dl respectively.

The ERPF values of the two radiopharmaceuticals were not significantly different ($p < 0.01$) when the calculations were made using Schlegel's program, modified by the introduction of 0.67 as a constant. The calculation is as follows.

$$ERPF = 5.029 \times BSA \times Return\ (0.67),$$

where BSA is body surface area and Return is total predicted return (8). Global ERPF values for all 13 patients are shown in Table I. A plot of ERPF values calculated from ^{99m}Tc-MAG3 versus those calculated from [^{131}I]OIH is shown in Figure 1. The regression equation was Y = 0.946657X + 15.9192, with a correlation coefficient of 0.997.

On the last patient studied, blood sample determinations were also performed for ^{99m}Tc-MAG3 and [^{131}I]OIH in addition to the ERPF camera method calculations, in order to make a more complete comparison. The camera method results were 625 ml/min and 687 ml/min respectively. The 1-sample determinations, drawn at 45 min, were 658 ml/min and 633 ml/min respectively.

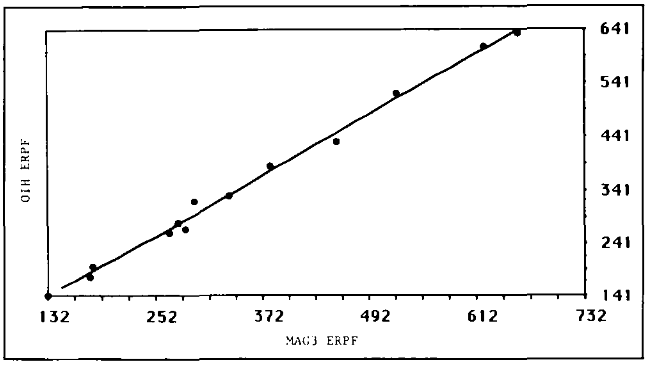

FIG. 1. Comparison between ^{99m}Tc-MAG3 and [^{131}I]OIH.

DISCUSSION

As described in the literature, the procedure for calculating ERPF with OIH is to use the injected dose and the reciprocal of the plasma concentration at a predetermined time (44 min) post injection (9). The published methods determine the fraction of the injected dose remaining in the plasma sample through the preparation of standard solutions each time a study is done. This adds additional time to the test and introduces the possibility of error associated with repeated preparation of standards. Although simplified techniques have been described (10, 11), the preparation of a standard solution is still needed.

The calculation of ERPF by the gamma camera alone has the distinct advantage of being easy to perform and does not require blood samples or the tedious preparation of standards.

Since renal function has been reported to be influenced by hydration, high blood pressure, salt intake, time of day, diet, and even physiological and emotional stress (12), it was felt that a fair comparison of the two compounds required performing the injections in sequential manner, not a simultaneous technique. It has been suggested that tracer administration of [^{131}I]OIH could interfere with the clearance of ^{99m}Tc-MAG3 (1).

Of the four different constants used (0.56, 0.57, 0.61, and 0.67), with correlation coefficients of 0.997357, 0.997293, 0.996769, and 0.997350 respectively, 0.67 gave the best results for predicting ERPF values with ^{99m}Tc-MAG3, compared to those obtained with [^{131}I]OIH. See Table 1.

The results presented show that Schlegel's determinations of ERPF can be applied to ^{99m}Tc-MAG3 without obtaining any blood samples. Although this conclusion is based on a limited number of patients, it does indicate the possibility of making such an adaptation, just as the blood sample technique requires the introduction of a proportionality constant.

TABLE 1. Global ERPF Values for Tc-99m MAG3 and I-131 OIH

Patient #	Sex	Age	ERPF (ml/min) MAG3	ERPF (ml/min) OIH
1	F	17	381	385
2	M	63	267	261
3	F	54	296	321
4	M	26	456	432
5	F	41	524	521
6	M	74	179	175
7	F	17	621	608
8	F	74	132	141
9	M	52	285	269
10	F	59	181	196
11	F	37	277	281
12	M	67	335	331
13	M	27	658	633

Referring diagnosis and number of patients: Diabetes (2), Proteinuria (2), Hypertension (3), Obstruction (2), Chronic renal insufficiency (1). BUN range: 10.1 to 87. Creatinine range: 0.7 to 13.

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