Changes in Patterns of ^{99m}Tc-Macroaggregated Albumin Use Between 2000 and 2015

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Since the early 2000s, the method of evaluating pulmonary embolism has shifted from ^{99m}Tc-macroaggregated albumin (MAA) perfusion lung scans to CT angiography. ^{99m}Tc-MAA continues to be applied for patients with contraindications to CT angiography and for other uses. A reduced number of ^{99m}Tc-MAA particles is administered to patients with pulmonary hypertension or other risk factors. This study assessed the changing patterns of ^{99m}Tc-MAA use between 2000 and 2015 at a single institution by comparing snapshots of the procedures performed in those two years. **Methods:** Records for all patients receiving ^{99m}Tc-MAA in 2000 and 2015 were reviewed, making note of the type of imaging procedure, whether there was any contraindication to CT angiography, and whether a reduced number of ^{99m}Tc-MAA particles was administered. **Results:** In 2000, ^{99m}Tc-MAA was used for 489 lung scans for pulmonary embolism, 2 for peritoneovenous shunts, and 1 for a cardiac shunt. Of the lung scan patients, 46 (9%) had pulmonary hypertension. A reduced number of particles was administered to the pulmonary hypertension and cardiac shunt patients (47/492, or 9%). In 2015, ^{99m}Tc-MAA was used for 263 lung scans for pulmonary embolism, 33 for presurgical planning, 33 for patients with a lung transplant, 16 for pulmonary artery stenosis, 5 to determine hepatic artery microsphere eligibility, and 1 for a peritoneovenous shunt. Of the lung scans for pulmonary embolism, 256 of the 263 patients (97%) had a contraindication to CT angiography or a nondiagnostic CT angiogram, including 99 (38%) with pulmonary hypertension. A reduced number of particles was administered to the pulmonary hypertension patients, presurgical patients, and lung-transplant patients (165/351, or 47%). **Conclusion:** Comparing 2015 with 2000, lung scans for pulmonary embolism decreased 46%, from 489 to 263, apparently because of a shift to CT angiography, whereas other uses rose from 3 to 88. Administration of a reduced number of particles rose significantly from 9% to 47% of ^{99m}Tc-MAA doses. Although the total number of ^{99m}Tc-MAA doses dropped 29%, from 492 to 351, ^{99m}Tc-MAA remains an important radiopharmaceutical for both pulmonary embolism and other uses.

Key Words: ^{99m}Tc-MAA; lung scans; MAA particles; macroaggregated albumin

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Since its introduction in the mid-1960s, ^{99m}Tc-albumin aggregated (commonly known as macroaggregated albumin, or MAA) has served as a valuable radiopharmaceutical in the evaluation of lung perfusion. Especially when coupled with radioactive gas or radioaerosol airway imaging, ventilation–perfusion (V/Q) lung scans have been a mainstay in the evaluation of pulmonary embolism (*1*). With the development of spiral CT in the mid-1990s and its widespread adoption in the early 2000s, there has been a dramatic shift from V/Q lung scans to CT angiography for evaluation of pulmonary embolism (*1*). However, ^{99m}Tc-MAA has continued to be used for V/Q scans, especially for patients with contraindications to CT angiography (*1,2*), and has found utility in a variety of other uses such as evaluation of pulmonary artery stenosis, evaluation of lung transplants, presurgical planning, and determination of eligibility for ^{90}Y microsphere intravascular brachytherapy (*3–5*).

Severe pulmonary hypertension is a labeled contraindication to the use of ^{99m}Tc-MAA, and right-to-left cardiac shunting is listed as a precaution (*6*). In these situations, professional practice guidelines recommend administering a reduced number of particles (*3,5*).

The objective of this study was to assess the changing patterns of ^{99m}Tc-MAA use by comparing snapshots of procedures in 2000 and 2015 in a single institution.

MATERIALS AND METHODS

The chair of the institutional review board determined that this study did not require review by the board or, accordingly, informed consent.

The medical records for all patients receiving ^{99m}Tc-MAA in 2000 and 2015 were reviewed. Note was made of the type of imaging procedure, whether there was any contraindication to CT angiography, and whether a reduced number of ^{99m}Tc-MAA particles was ordered. The results were tabulated separately for each year. A 2-proportion z test ($\alpha = 0.05$) was used to evaluate whether there were statistically significant changes in the fraction of patients receiving a reduced number of ^{99m}Tc-MAA particles.

RESULTS

The uses of ^{99m}Tc-MAA and their respective frequencies in 2000 and 2015 are detailed in Table 1.

In 2000, 46 (9.4%) of the 489 V/Q patients were given a reduced number of ^{99m}Tc-MAA particles because of pulmonary hypertension. A reduced number of particles was also

TABLE 1
^{99m}Tc-MAA Uses in 2000 and 2015

Use	Number	
	2000	2015
V/Q scan, routine number of particles	443 (90.0%)	164 (46.7%)
V/Q scan, reduced number of particles	46 (9.3%)	99 (28.2%)
Peritoneal–venous shunt patency	2 (0.4%)	1 (0.3%)
Right-to-left cardiac shunt	1 (0.2%)	
Pulmonary artery stenosis		16 (4.6%)
Presurgical evaluation		33 (9.4%)
Lung transplants		33 (9.4%)
Hepatic artery microsphere eligibility		5 (4.6%)
Total	492 (100%)	351 (100%)

used for the cardiac shunt patient. Thus, of the 492 patients who received ^{99m}Tc-MAA, 47 (9.6%) were given a reduced number of particles.

In 2015, 99 (37.6%) of the 263 VQ patients were given a reduced number of ^{99m}Tc-MAA particles because of pulmonary hypertension. A reduced number of particles was also used for the 66 presurgical and lung-transplant patients. Thus, of the 351 patients who received ^{99m}Tc-MAA, 165 (47.0%) were given a reduced number of particles.

Statistical analyses using 2-proportion z tests showed that between 2000 and 2015, there was a significant increase in the fraction of patients receiving a reduced number of particles for V/Q scans ($z = 9.4$, $P < 0.01$) and in the fraction receiving a reduced number of particles for any reason ($z = 10.7$, $P < 0.01$).

As shown in Table 1, the number of V/Q scans substantially decreased from 2000 to 2015, presumably because of a shift to CT angiography. Of the V/Q scans in 2015, most were performed because the patient had a contraindication to CT angiography (Table 2).

There was also an increase in the variety and number of other uses of ^{99m}Tc-MAA in 2015, compared with 2000 (Table 1).

DISCUSSION

The Food and Drug Administration–approved indications for ^{99m}Tc-MAA are evaluation of lung perfusion and evaluation of peritoneovenous (LeVeen) shunt patency (*6*). ^{99m}Tc-MAA imaging after hepatic artery injection, although an off-label use, is described as an eligibility test before treatment of liver tumors with ^{90}Y-microspheres (*7,8*).

The recommended dose for ^{99m}Tc-MAA in adults is 200,000–700,000 particles, with the suggested number being 350,000 (*6*). Severe pulmonary hypertension is a specific contraindication to ^{99m}Tc-MAA (*6*). However, the V/Q lung scan is considered a pivotal test in the definitive diagnosis and baseline characterization of pulmonary hypertension (*9*). Hence, V/Q scanning is routinely performed on patients with suspected or known pulmonary hypertension. In these patients, professional practice guidelines recommend using a reduced number of particles, such as 100,000–200,000 (*3*) or 100,000–150,000 (*5*). Doses with a reduced number of particles are also used in patients who have right-to-left cardiac shunts (*3*) or lung transplants (*10*) or who are to undergo lung surgery (unpublished institutional policy). Such reduced-particle doses generally require that the ^{99m}Tc-MAA not be prepared according to the package insert instructions (*11,12*). Doses with a reduced number of particles were relatively rare in 2000 (9%) but became much more frequent by 2015 (47%).

TABLE 2
Contraindications to CT Angiography in Patients Undergoing V/Q Scans in 2015

Contraindication	Number
None	7 (2.7%)
Acute kidney injury or chronic kidney disease	121 (46.0%)
Contrast allergy	18 (6.8%)
Pregnancy	6 (2.3%)
Metformin therapy not stopped	2 (0.8%)
Intravascular hypovolemia	1 (0.4%)
Pulmonary hypertension	99 (37.6%)
Heart transplant	2 (0.8%)
Nondiagnostic CT angiography	7 (2.7%)
Total	263 (100%)

Although CT angiography has replaced V/Q scanning to a large extent, V/Q scanning remains an important option for patients who have a nondiagnostic CT angiogram or a relative contraindication to CT angiography. Such patients include those who are pregnant; those who have kidney disease or impaired renal function (e.g., chronic renal insufficiency or acute kidney injury), a contrast allergy or a previous reaction to contrast medium, intravascular hypovolemia, pulmonary hypertension, or heart-transplant rejection; and those who are on uninterrupted metformin therapy (*2,13*). In 2015, 97% of our V/Q patients had a relative contraindication to CT angiography or a nondiagnostic CT angiogram (Table 2).

Data on the use of ^{99m}Tc-MAA were limited to snapshots of two years in a single institution. The results cannot be extrapolated to other institutions. Nonetheless, articles in the literature and professional practice guidelines suggest that the ^{99m}Tc-MAA lung scan remains an important, albeit less frequently performed, diagnostic test for pulmonary embolism, especially if the patient has a contraindication to radiopaque contrast media. Moreover, there appear to be a growing number of other uses.

CONCLUSION

Comparing 2015 with 2000, the number of ^{99m}Tc-MAA lung scans for pulmonary embolism dropped from 489 to 263 (a 46% decrease), apparently because of a shift to CT angiography, whereas the number of other uses rose from 3 to 88. Administration of a reduced number of particles rose significantly, from 9% of doses to 47% of doses. Although the total number of ^{99m}Tc-MAA doses dropped from 492 to 351 (a 29% decrease), ^{99m}Tc-MAA remains an important radiopharmaceutical for pulmonary embolism and other uses.

DISCLOSURE

No potential conflict of interest relevant to this article was reported.

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