Continuing Medical Education Article

From the Angio Suite to the γ-Camera: Vascular Mapping and ⁹⁹ᵐTc-MAA Hepatic Perfusion Imaging Before Liver Radioembolization—A Comprehensive Pictorial Review

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Disclosure
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Target Audience
This article contains information of value to nuclear medicine and diagnostic radiology residents, interventional radiology fellows, and specialists in these fields. It provides a comprehensive illustrative review of the procedure and practical updates.

Objectives
On successful completion of this activity, participants should be able to describe…

1. The rationale and the aims of conjoint endovascular mapping and ⁹⁹ᵐTc-macroaggregated albumin (⁹⁹ᵐTc-MAA) hepatic perfusion imaging before liver radioembolization.

2. How to integrate the information gathered during the angiographic procedure with the SPECT/CT hepatic perfusion study to generate an interpretation relevant to clinical management.

3. Various sites of ⁹⁹ᵐTc-MAA activity outside the liver parenchyma and their potential origin in order to avoid nontargeted radioembolization.

4. Pitfalls in ⁹⁹ᵐTc-MAA hepatic perfusion imaging and how to avoid them.

Questions
1. Preferential delivery of $^{90}$Y-microspheres to hepatic malignancies is due to a preferential blood supply to the tumors via…
A. Portal veins and normal microvasculature at the periphery of the lesions.
B. Hepatic arteries and normal microvasculature at the periphery of the lesions.
C. Portal veins and dense microvasculature at the periphery of the lesions.
D. Hepatic arteries and dense microvasculature at the periphery of the lesions.

2. Which is true regarding a $^{90}$Y-radioisotope?
A. $^{90}$Y decays purely by $\beta^-$ emission.
B. $^{90}$Y decays purely by $\beta^+$ emission.
C. $^{90}$Y decays by $\beta^-$ emission and a minor branch of internal pair production.
D. $^{90}$Y decays by $\beta^+$ emission and a minor branch of internal pair production.

3. Which statement is true regarding gastric activity in $^{99m}$Tc-MAA hepatic perfusion imaging before liver radioembolization?
A. Diffuse activity outlining the gastric mucosa with renal, thyroid, and salivary gland activity is indicative of free $^{99m}$Tc-pertechnetate.
B. Free $^{99m}$Tc-pertechnetate can be imaged either as focal activity in the stomach wall or as diffuse activity in the gastric mucosa.
C. Unintended extrahepatic perfusion to the stomach via the right gastric artery is typically seen as focal activity in the greater curvature of the stomach.
D. Any gastric activity regardless of distribution is potentially extrahepatic and should be further interrogated before the actual treatment.

4. Which of the following statements is true regarding the falciform artery?
A. It originates from the left hepatic artery to supply blood to the falciform ligament.
B. Its nontargeted radioembolization may potentially cause pain and radiation dermatitis at the supraumbilical region.
C. It may originate from the right hepatic artery or the middle hepatic artery.
D. Extrahepatic perfusion via this vessel is seen as $^{99m}$Tc-MAA activity tracking from the lower edge of the falciform ligament to the body of the pancreas.
5. $^{99m}$Tc-MAA hepatic perfusion imaging showing focal activity in the proximal two thirds of the duodenum should be interpreted as extrahepatic perfusion most probably because of which vessel?
A. Right gastric artery.
B. Retroduodenal artery.
C. Supraduodenal artery.
D. Left pancreatic artery.

6. Which of the following will most affect the calculated percentage of lung shunting?
A. Known arteriovenous malformation in the left upper extremity.
B. Presence of recently administered $^{90}$Y-microspheres in the liver.
C. Presence of free $^{99m}$Tc-pertechnetate from biodegraded $^{99m}$Tc-MAA.
D. Lack of a background region of interest for the lung counts.

7. Which organs most commonly accumulate radioactivity when biodegradation of the $^{99m}$Tc-MAA particles occurs?
A. Thyroid gland, brain, and gastric mucosa.
B. Gastric wall, gallbladder, and kidney.
C. Thyroid gland, kidneys, and gastric mucosa.
D. Thyroid gland, kidneys, and gallbladder.

8. Which of the following statements is true regarding detecting sites of extrahepatic perfusion in hepatic perfusion imaging with SPECT/CT versus SPECT only?
A. SPECT/CT has higher sensitivity.
B. SPECT/CT has lower specificity.
C. SPECT/CT has lower accuracy.
D. SPECT/CT has similar sensitivity.

9. When $^{90}$Y-microspheres and $^{99m}$Tc-MAA are administered concurrently before SPECT/CT, how do the $\beta^-$ particles from $^{90}$Y affect the quality of $^{99m}$Tc-MAA images?
A. It is not affected, because $\beta^-$ particles will not reach the detectors.
B. It is not affected, but the internal pair production decay creates 511-keV photons that improve the image resolution.
C. It is degraded, because $\beta^-$ particles induce broad-spectrum bremsstrahlung radiation that can penetrate the collimator and reach the detector.
D. It is improved, because $\beta^-$ particles induce bremsstrahlung radiation and more photons will reach the detectors.

10. A 47-y-old man with colon cancer metastatic to the liver underwent vascular mapping and a $^{99m}$Tc-MAA hepatic perfusion study before anticipated liver radioembolization with $^{90}$Y-microspheres. A representative fused SPECT/CT image of the abdomen (A) and the angiographic images (B and C) are shown below. Which of the following statements best describes the findings?

A. Extrahepatic perfusion via a falciform artery emerging from the right vascular territory.
B. Extrahepatic perfusion via a falciform artery emerging from the left vascular territory.
C. No extrahepatic perfusion but rather misregistration of the SPECT and CT images.
D. Extrahepatic perfusion via a recruited vessel from the right internal mammary artery.

11. A 47-y-old man with colon cancer metastatic to the liver underwent vascular mapping and a $^{99m}$Tc-MAA hepatic perfusion study before anticipated liver radioembolization with $^{90}$Y-microspheres. A representative fused SPECT/CT image of the abdomen (A) and the angiographic images (B and C) are shown below. Which of the following statements best describes the angiographic finding in B and C?

A. Standard arterial anatomy with coils in the right gastric artery.
B. Replaced left hepatic artery with coils in the gastroduodenal artery.
C. Replaced right hepatic artery with coils in the gastroduodenal artery.
D. Standard arterial anatomy with coils in the gastroduodenal artery.
12. With concurrent administration of $^{90}$Y-microspheres and $^{99m}$Tc-MAA, which collimator should be used to optimize the $^{99m}$Tc-MAA images?
   A. High-energy collimator.
   B. Medium-energy collimator.
   C. Low-energy all-purpose collimator.
   D. Low-energy high-sensitivity collimator.

13. What is the mean path length in soft tissue of the $\beta^-$ particles emitted by $^{90}$Y?
   A. 2.5 mm.
   B. 5.0 mm.
   C. 7.5 mm.
   D. 10.0 mm.

14. A plane through the falciform ligament projecting on the path of the left hepatic vein divides which parts of the liver?
   A. Right hemiliver and left hemiliver.
   B. Lateral section and the medial section of the left hemiliver.
   C. Anterior section and posterior section of the right hemiliver.
   D. Superior and inferior segments.

15. Which normal variant of hepatic arterial anatomy can perfuse only the anterior section of the right hemiliver (segments 5 and 8)?
   A. A replaced right hepatic artery from the superior mesenteric artery.
   B. A replaced left hepatic artery from the left gastric artery.
   C. An accessory right hepatic artery from the superior mesenteric artery.
   D. An accessory left hepatic artery from the left gastric artery.