Yttrium-90 Radioembolization of the Right Inferior Phrenic Artery in 20 Patients with Hepatocellular Carcinoma

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ABSTRACT

Purpose: To address the feasibility of infusion of yttrium-90 (^{90}Y) glass microspheres directly through the right inferior phrenic artery (RIPA).

Materials and Methods: From November 2015 to May 2017, 20 patients underwent ^{90}Y radioembolization through the RIPA. When the systemic-to-pulmonary shunt was demonstrated on C-arm computed tomography (CT) of the RIPA, prophylactic embolization by polyvinyl alcohol (PVA) particles was performed prior to infusion of ^{90}Y glass microspheres. Follow-up CT scans were retrospectively reviewed for pulmonary complications. Tumor response was determined by the modified Response Evaluation Criteria in Solid Tumors.

Results: Nine (45%) patients had systemic-to-pulmonary shunts on C-arm CT images of the RIPA. The feeder of the systemic-to-pulmonary shunt was the azygoesophageal branch (n = 7) and the anterior branch (n = 2). The mean activity of ^{90}Y glass microspheres infused into the RIPA was 0.49 GBq (range, 0.19–1.55 GBq). No patient had symptomatic radiation pneumonitis or cutaneous complications during follow-up. Seven patients had focal atelectasis (n = 5), focal ground-glass opacity (n = 2), and/or a small amount of pleural effusion (n = 2) on follow-up image. Best tumor response fed by the RIPA was complete response (n = 4), partial response (n = 9), stable disease (n = 2), progressive disease (n = 4), and unevaluable (n = 1).

Conclusion: The administration of ^{90}Y glass microspheres through the RIPA may be safe after embolization of a systemic-to-pulmonary shunt identified on C-arm CT.

ABBREVIATIONS

HCC = hepatocellular carcinoma, PVA = polyvinyl alcohol, RIPA = right inferior phrenic artery, ^{90}Y = yttrium-90

INTRODUCTION

Radioembolization with yttrium-90 (^{90}Y) microspheres is commonly performed for patients with unresectable hepatocellular carcinoma (HCC) (1–3). To achieve favorable outcomes, adequate distribution of microspheres throughout the entire tumor is the important factor. Up to 30% of HCC patients may have blood supply from extrahepatic collateral arteries, and the right inferior phrenic artery (RIPA) is the most common collateral artery (4–7).

Whereas some literature suggests that chemoembolization through the RIPA is safe (4–7), there are little data on radioembolization through the RIPA. Burgmans et al reported that administration of radioactive microspheres via the RIPA is safe, but only 5 patients received delivery of radioactive microspheres into the RIPA of 21 patients with tumors supplied by the RIPA (8). Although Abdelmaksoud et al insisted that redistribution of arterial flow to the hepatic tumor by embolization of extrahepatic collateral arteries was safe and effective (9), it is possible that redistribution may not be established, or other collateral arteries may take over blood supply to the tumor.

In a study that employed C-arm computed tomography (CT), the RIPA accompanied systemic-to-pulmonary shunts in 69% of patients (10). We hypothesized that it may be safe to administer radioactive microspheres into the RIPA after embolization of systemic-to-pulmonary shunts. The aim of

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None of the authors have identified a conflict of interest.

J Vasc Interv Radiol 2018; 29:556–563

https://doi.org/10.1016/j.jvir.2017.10.010

this retrospective study was to address the feasibility of infusion of ^{90}Y glass microspheres directly through the RIPA.

MATERIALS AND METHODS

Patients

The institutional review board approved this retrospective study and permitted the waiving of informed consent. Radioembolization rather than chemoembolization was commonly recommended by physicians for HCC patients with a large tumor or vascular invasion. All patients were informed that radioembolization has similar overall survival, longer progression-free survival, and results in better quality of life compared with chemoembolization and was not reimbursed by national health insurance. The treatment strategy (radioembolization versus chemoembolization) was determined by physician recommendations and patient choice.

From November 2015 to May 2017, 79 patients with HCC underwent ^{90}Y radioembolization using glass microspheres (TheraSphere; BTG, London, United Kingdom) in our institute. Of the 79 patients, 22 (28%) had a tumor supplied by the RIPA. Conventional chemoembolization was performed via the RIPA for the first 2 patients, and ^{90}Y radioembolization was undertaken via the RIPA for the remaining consecutive 20 patients (13 men and 7 women; mean age, 56.3 years). The demographics of the 20 patients who underwent ^{90}Y radioembolization through the RIPA are summarized in the **Table**. Two (10%) patients had a single nodular tumor, 11 (55%) had multiple nodular tumors, and 7 (35%) had infiltrative tumors. Eleven (55%) patients had portal vein invasion. The proportion of blood supply by the RIPA was less than 10% of tumor volume in 13 (65%) patients.

Planning Angiography and Technetium Macroaggregated Albumin Imaging

Planning angiography with C-arm CT equipment (Axiom Artis dTA/VB30 or Artis Zee; Siemens Healthcare, Forchheim, Germany) was undertaken in all patients prior to ^{90}Y radioembolization. C-arm CT images were obtained at the proper hepatic artery or equivalent (11,12). If part of the tumor was not enhanced on C-arm CT image of the proper hepatic artery, blood supply from extrahepatic collateral artery was suspected. Then, selective angiography of possible extrahepatic collateral arteries, including the RIPA, was performed. When tumor staining was seen or suspected on selective angiography of an extrahepatic collateral artery, C-arm CT of the extrahepatic collateral artery was obtained to confirm blood supply. One hundred eighty-five MBq of technetium macroaggregated albumin (^{99m}Tc-MAA) was infused via the right hepatic artery, and ^{99m}Tc-MAA was not infused into the RIPA. Afterwards, ^{99m}Tc-MAA whole-body scan images and single-photon emission computed tomography/CT images were obtained using a hybrid scanner (Discovery NM/CT 670; GE Healthcare, Illinois) (13).

^{90}Y Radioembolization

A 1.8-Fr microcatheter (Carnelian, Tokai Medical Products, Kasugai, Japan) was used to catheterize the RIPA. Based on the planning angiography and C-arm CT images of the RIPA, the operator (H.-C.K., with 11 years of experience in interventional oncology) determined the presence of systemic-to-pulmonary shunt and its feeding artery, as well as tumors supplied by the RIPA. The systemic-to-pulmonary shunt was considered present 1) when opacification of the pulmonary artery showing back and forth filling of contrast media was noted on early phase of angiography, and wash-out of the pulmonary artery and faint opacification of the pulmonary vein was visualized on delayed phase; and 2) when linear pulmonary vascular structure was opacified on C-arm CT with or without surrounding pulmonary parenchymal staining.

If the azygoesophageal branch was present, it was embolized with 45–150 μm polyvinyl alcohol (PVA) particles (Contour; Boston Scientific, Natick, Massachusetts) prior to infusion of radioactive microspheres. If the anterior branch or posterior branch supplied systemic-to-pulmonary shunts and selective embolization of shunts is feasible, a feeding artery of systemic-to-pulmonary shunts was embolized with PVA particles. If the anterior or posterior branch fed both systemic-to-pulmonary shunts and tumors, and selective embolization of shunts was not feasible, embolization with PVA particles was performed for a large shunt and was not undertaken for a small shunt. The large shunt was defined as opacification of segmental or subsegmental pulmonary artery or vein. The shunt was considered small when only terminal pulmonary vessels were opacified on C-arm CT. Radioactive microspheres were infused at the proximal RIPA just distal to the origin of the superior adrenal artery after shunt embolization. If the distal anterior or posterior branch did not supply the tumor, and fine tumor feeders originating from the proximal RIPA supplied the tumor, the distal anterior or posterior branch were embolized with PVA or gelatin sponge particles prior to infusion of radioactive microspheres to reduce irradiation to normal tissue and enhance deposition of radioactive microspheres into the tumor.

The dose infused via the RIPA was calculated assuming that shunt fraction was the same as for the hepatic artery. Dose calculation was based on the medical internal radiation dose method recommended by the manufacturer of glass radioactive microspheres. Infusion of radioactive microspheres through the RIPA and the hepatic artery was performed in the same session. The administration schedule of glass radioactive microspheres was determined as the appropriate date for the hepatic artery with the desired dose of 100~150 Gy to perfused tissue. Because volume fed by the RIPA is much smaller than that by the hepatic artery, a vial of 3 GBq at calibration was infused into the RIPA in most cases, having 0.2~0.5 GBq of radioactivity at administration depending on the treatment schedule.

Immediately after ^{90}Y radioembolization, hybrid positron emission tomography (PET)/CT imaging (Biograph 40; Siemens Medical Solutions, Knoxville, Tennessee) was