Outpatient Single-Session Yttrium-90 Glass Microsphere Radioembolization

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ABSTRACT

Purpose: To investigate the feasibility of yttrium-90 (^{90}Y) glass microsphere radioembolization (including angiography, lung shunt assessment, and treatment) as a single-session, outpatient procedure.

Materials and Methods: Between January 2008 and June 2013, 14 patients underwent outpatient, single-session radioembolization with ^{90}Y glass microspheres. As part of the routine diagnostic work-up, all patients underwent either computed tomography (CT) or magnetic resonance imaging of the liver with three-dimensional analysis and had laboratory results forwarded to our center for confirmation of candidacy before treatment. On treatment day, all patients underwent planning mesenteric angiography with flat panel cone-beam CT imaging. Patients were administered 33–85 MBq of technetium-99m macroaggregated albumin (^{99m}Tc-MAA) via a microcatheter positioned in a hepatic artery supplying the tumor of interest. Planar scintigraphy was initiated within 2 hours after the administration of ^{99m}Tc-MAA and lung shunt fraction was determined. Final dosimetry calculations were performed while the patient was being transferred back from nuclear medicine to interventional radiology.

Results: All patients successfully underwent planning angiography with administration of ^{99m}Tc-MAA and ^{90}Y radioembolization as a single-session treatment. There were no reportable or recordable medical events; treatment was carried out to the desired dose in all cases. The mean total procedure time was 2.70 hours ± 0.72 (range, 1.63–3.97 h).

Conclusions: This study reports a novel proof of concept for performing radioembolization in a single-session setting. By using the described method, time between initial clinical assessments and radioembolization treatment is decreased, and costs are minimized.

ABBREVIATIONS

DSA = digital subtraction angiography, LSF = lung shunt fraction, MIRD = medical internal radiation dose, SPECT = single photon emission computed tomography, ^{99m}Tc-MAA = technetium-99m macroaggregated albumin, ^{90}Y = yttrium-90

Current radioembolization treatment of hepatic tumors with yttrium-90 (^{90}Y) glass microspheres involves at least a two-step process that spans 2 weeks. To determine the activity to be administered to the patient, treatment planning angiography and nuclear medicine imaging using technetium-99m macroaggregated albumin (^{99m}Tc-MAA) are performed before radioembolization to assess lung shunting and extrahepatic uptake. This imaging is widely recognized to be important for minimizing the risk of potentially debilitating adverse events, such as radiation-induced pneumonitis or radiation gastritis or duodenitis (1,2). After planning dosimetry, activity vials are ordered, and treatment is completed in the next 1–2 weeks. This paradigm has become the standard of care for ^{90}Y glass microsphere radioembolization (3,4). However, time delay and potential costs are inherent in this approach. As a first step, the patient must undergo a planning angiogram with digital subtraction angiography (DSA) and flat panel cone-beam computed tomography (CT) followed by nuclear medicine imaging including planar and single photon emission computed tomography (SPECT)/CT imaging. The patient must

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return the following week for another angiogram and treatment.

Meticulous review of cross-sectional imaging with three-dimensional vascular enhancing software permits determination beforehand of the number of source vials required to carry out radioembolization. Confirmation of the anatomy using DSA and cone-beam CT is performed on treatment day, permitting a low-toxicity profile, increased response rates, and low incidence of complications after treatment for patients (5). The purpose of the present study is to demonstrate, as proof of concept, that radioembolization treatment of unresectable hepatic tumors can be performed safely as a single-session, outpatient procedure.

MATERIALS AND METHODS

Patient Cohort

Between January 2008 and June 2013, 14 patients underwent outpatient, single-session radioembolization with ^{90}Y glass microspheres (TheraSphere; Nordion, Ottawa, Ontario, Canada) for treatment of hepatic tumors. Five patients were treated for metastatic disease of the liver (one patient with colorectal cancer, one patient with neuroendocrine disease, one patient with cholangiocarcinoma, one patient with breast cancer, and one patient with hepatoblastoma). Nine patients were treated for hepatocellular carcinoma. Patients selected for same-day, single-session radioembolization included patients with travel limitations (out of country or state) or with rapidly progressive disease necessitating timely treatment. Institutional review board approval for data analysis was obtained.

Treatment Work-up

As part of the routine diagnostic work-up before radioembolization treatment, all patients underwent either CT or magnetic resonance imaging of the liver with three-dimensional reconstruction of images and had laboratory tests performed before scheduling the treatment date (3). Because all of these patients resided outside our local treatment region, these results were forwarded to our center for evaluation of the patient's candidacy for radioembolization. Once confirmed, using Vitrea (Toshiba Medical Systems, Tokyo, Japan) volume analysis software, the treatment volume and number of primary vessels supplying the treatment volume were acquired. Based on the resulting volumes and the assumption of 10% lung shunt fraction (LSF) (percent liver to lung shunt) for hepatocellular carcinoma and 5% LSF for liver metastases, the source vials required for the treatment dose based on the medical internal radiation dose (MIRD) method were ordered. Despite meticulous review of the outside films with three-dimensional reconstruction, we recognized the possible margin of error in (*i*) LSF and (*ii*) identification of accessory small vessels perfusing the tumor, and one to two extra source vials were ordered to account for this possible margin of error. Per the manufacturer's long-standing policy, no additional cost for the extra vials is incurred because the cost per patient dosage is based on the entire planned treatment on that day (regardless of the number of vials ordered or infused).

On the day of treatment, all patients underwent treatment planning mesenteric angiography as previously described (6,7). Patients also underwent cone-beam CT imaging to determine tumor coverage and assess hepaticoenteric arterial communications that would lead to the deposition of microspheres to extrahepatic tissue. To visualize small vessels and vessels that may demonstrate reversal of flow (ie, result of flow shunt or sumping secondary to hypervascular tumor), dedicated microcatheter injections with high rates (2–3 cm^3/s for 8–12 cm^3) were performed during the planning angiogram and the treatment angiogram. In addition, cone-beam CT with contrast material administered through the microcatheter in place for the treatment was performed to demonstrate coverage of the tumor within the treatment volume as well as a final screening for hepaticoenteric arterial communications.

After three-dimensional anatomy was confirmed, all patients were administered 33–85 MBq of ^{99m}Tc-MAA via a microcatheter positioned in a hepatic artery supplying the tumor of interest. The microcatheter was subsequently removed (vascular access sheath maintained in position), and the entire team (fellow, nurse, technologist) transported the patient to the nuclear medicine department to ensure continuity of care and to monitor the vascular access sheath. Planar scintigraphy was initiated within 2 hours after administration of ^{99m}Tc-MAA. For planar imaging, the patient was positioned supine under the gamma camera, and four images were acquired: anterior and posterior images of the abdomen and anterior and posterior images of the thorax. One additional image was obtained using a cobalt-57 sheet source as a transmission source so that the contour of the body and lungs could be visualized. Liver activity shunted to the lungs was determined from the background corrected geometric mean counts from region of interest drawn on planar images using a syngo workstation (VE25A; Siemens Healthcare, Munich, Germany). The patient then was transferred back to interventional radiology. Final dose calculations were performed during the transit time from nuclear medicine to radiology. The final written directive was signed; all patients underwent radioembolization.

Treatment Dosage Determination and Ordering

Treatment dosage was determined using the MIRD method per the manufacturer's recommendations. Because