Siemens Imaging Solutions Facilitate New Radiation Therapy Approach to Liver Cancer

Using yttrium-90 microspheres is a new intraarterial therapy that uses beta-irradiating microspheres directly delivered to the tumor. The procedure demands the use of technologically advanced imaging equipment. A case study.

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Most patients with colorectal, breast, lung, hepatocellular, and pancreatic cancers are at risk to recur from metastatic disease in the liver after potentially curative treatment. When the liver does harbor metastatic or primary cancer, treatment options and ultimately their chances of survival rapidly decline. That is in part because the liver is at once amazing in its ability to grow larger (hypertrophy) and challenging that it is so easily damaged by chemotherapy, radiation therapy, and local surgical techniques. Unfortunately, uncontrolled and eventually fatal liver disease is the final common pathway for nearly half of all patients with colorectal cancer and the majority of those with hepatocellular cancer. It is a worldwide health issue and a leading cause of premature death.

Anticancer Treatment Moves Forward With Imaging

There is new hope in the struggle to eradicate cancer from the liver using cutting-edge imaging technology to assist in delivery of microscopic radioactive spheres. A multimodality tour de force enables this exciting new approach that utilizes the skills and expertise of several specialties, including diagnostic radiology, interventional radiology, radiation oncology, and nuclear medicine, to safely administer the radiation directly into the tumors in the liver. Physicians are impressed and encouraged by the early results of the therapy, and patients remark on its ease, minimal side effects, and especially the same-day discharge as the procedure. None of this would be possible without the latest in imaging technology to localize the tumor, evaluate its extent, confirm the safety of future microsphere treatment, and confirm treatment success. In addition to PET-CT imaging, hepatic angiography, macro-aggregated albumin scan, and thin-section liver CT are essential in proper case selection, treatment delivery, and follow-up assessment of treatment response.

Each microsphere is composed of resin and yttrium-90, a pure beta emitter, which only penetrates tissues up to one quarter inch. Therefore, when in the tumor, where they remain permanently, they will only destroy cancerous tissues, and spare the surrounding normal liver. A key feature of delivering microspheres to the tumor is the fact that 80 to 100 percent of the blood supply to metastases in the liver comes from the hepatic artery. The latest in microcatheters

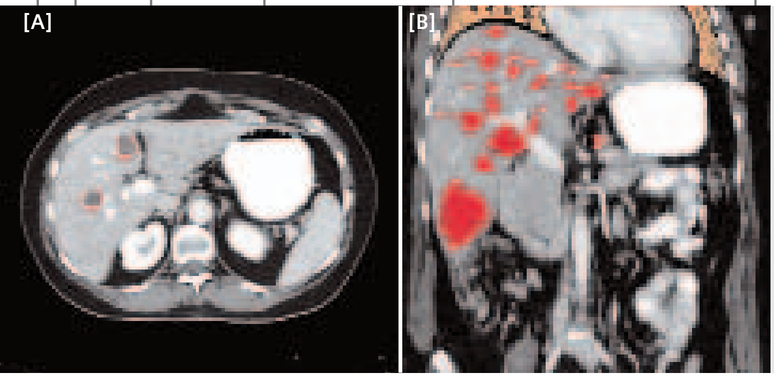

FIGURE 1:
[A] Axial CT image obtained on a Siemens SOMATOM CT scanner with 3-mm slice thickness, 1.5-mm reconstructions during a three-phase liver study. Tumor has been identified in red during radiation treatment planning.
[B] CT DICOM images were imported into a radiation treatment planning system for three-dimensional reconstruction and determination of tumor volume and normal liver volume, as a guide to selecting the most appropriate activity of ^{90}Y microspheres for this patient. This coronal image shows the distribution and size of tumor deposits during the venous phase of liver image acquisition.

and diagnostic interventional radiology C-arm technology allow for precise placement of radiation into small peripheral vessels. The amount of radiation delivered can be significant, but because the microspheres are only about 32 microns in diameter, they enter the tumor from the hepatic artery supply and preferentially collect in the periphery of tumor nodules. The capillary beds will only allow passage of particles that are less than 10 microns, thereby trapping the microspheres within the tumor. If an arteriovenous fistula or other abnormally large passageway between the arterial and venous vascular systems is present, radioactive spheres will pass into the next capillary bed: the pulmonary system. Lungs are very sensitive to radiation, and great damage can occur if a significant amount of microspheres escape the liver. The radioactive source ^{90}Y does not come off of the microspheres, so by containing the spheres to the tumor, the radiation is also localized to only that area.

Case Presentation

The patient is a 45-year-old woman who underwent surgery and postoperative chemotherapy for sigmoid colon adenocarcinoma, also diagnosed with unresectable synchronous liver metastases. State-of- the-art chemotherapy was delivered but the liver tumors were largely unaffected, and some even grew during treatment. Because of the extent and location of the lesions, surgery and other locally ablative approaches (i. e. radiofrequency ablation, cryotherapy, and laser ablation) were not recommended. Rather than receive salvage chemotherapy, her doctors chose to first use liver brachytherapy via ^{90}Y microspheres and chemotherapy together, then proceed with systemic chemotherapy.

Imaging is critical in all phases of internal radiation therapy. The treatment process starts with establishing the location, size, and volume of tumors in the liver. At the same time, there is also a search for any extra hepatic tumor deposits. Using a Siemens CTI PET-CT System, complementary information is obtained on the location and cellular activity of tumor deposits in three dimensions. High-resolution three-phase liver imaging is obtained with CT, followed by hepatic arterial system mapping internally with angiography. Next, the hepatic vasculature and potential release point of the microspheres are tested with a macroaggregated albumin scan ($^{99m\text{Tc}}$MAA), which uses the ubiquitous human serum protein albumin, processed into the same size as the radioactive microspheres, but bound to a gamma-emitting isotope for imaging instead of a beta source that is used for therapy, which cannot be easily imaged. The albumin particles lodge in the tumor just like the microspheres will, and thus a "simulation" of the treatment is performed to detect deposition of particles in the stomach, small bowel, or lungs instead of the intended target, the liver tumors. Corrective measures can then be taken to make microsphere delivery safer by avoiding extrahepatic spread. Finally, after microsphere delivery, a gamma camera is used to perform a postimplant scan, which detects the small amount of characteristic gamma X-rays released by ^{90}Y during beta decay to ^{90}Zr (stable).

The whole liver was treated with ^{90}Y microspheres and 5FU and Leucovorin chemotherapy intravenously. The patient tolerated the treatment well and was discharged the same day as treatment, returning to work fulltime in a few days. Her side effects were typical for this type of treatment: mild nausea and epigastric pain, with fatigue for several days, although some patients have these symptoms longer. The delivery of radiation to liver tumors is a step forward for oncologists and patients, made possible by precise imaging.

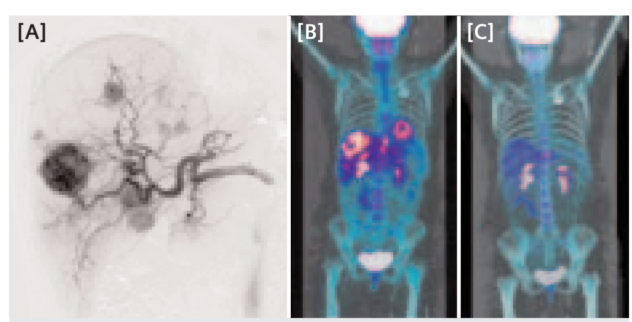

FIGURE 2:
[A] Contrast seen in the hepatic arterial system prior to release of ^{90}Y microspheres via digital image acquisition on a Siemens MultiStar™ C-arm system. Siemens FDG-PET and CT images before [B] and 8 weeks after [C] fused for 3-dimensional display and rotation for the medical team to fully appreciate tumor response. Little of the original tumors remain viable after microsphere radiation therapy. Uptake in the kidneys, brain, and bladder are physiologic, not tumorous.