Case Report

Intra-Arterial CT Angiography Visualization of Arterial Supply to Inferior Vena Cava Tumor Thrombus Prior to Radioembolization of Hepatocellular Carcinoma

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ABSTRACT

Unresectable hepatocellular carcinoma has a high frequency of vascular invasion and arterial parasitization. Trans-arterial radioembolization using yttrium-90 (Y90) microspheres is a possible treatment option. Paramount to its success is the meticulous angiographic interrogation of tumor feeding arteries and extra-hepatic supply. We describe a patient with tumor invasion of the inferior vena cava with arterial supply from the right inferior phrenic artery, which was exquisitely visualized using intra-arterial computed tomographic angiography (IACTA) during the planning technetium-99m macro aggregated albumin phase. This technique was useful in planning which artery to administer Y90 microspheres into for maximal brachytherapy. Although patient outcome was poor due to significant arterio-portal shunting, we believe that IACTA is a useful adjunct to conventional digital subtraction angiography in planning radioembolization therapy.

Key Words: Intra-arterial computed tomographic angiography, radioembolization, tumor thrombus

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Radioembolization using trans-arterial administration of yttrium-90 (Y90) microspheres has been used to treat unresectable hepatocellular carcinoma (HCC).[1] Trans-arterial therapy relies on the unique dual blood supply of the liver, with HCC receiving 80-100% of their blood supply from the hepatic artery rather than the portal vein.[2] However, extra-hepatic collateral arteries may also supply advanced HCC, especially in large tumors with tumor growth abutting the bare area or liver capsule.[3] In addition, HCC tends to invade the portal or hepatic veins, and up to 4% the inferior vena cava (IVC).[4] In a study of 82 patients with IVC tumor thrombi from HCC, 65.9% had extra-hepatic collateral arterial supply, with the right inferior phrenic artery being the most common source (87.0%).[4]

One of the recommendations from the Radioembolization Brachytherapy Oncology Consortium (REBOC) is the need for meticulous angiographic techniques in radioembolization.[5] A natural extension of this recommendation is the visualization of all extra-hepatic collateral arterial supply so as to optimize dosing and trans-arterial administration of Y90 microspheres. Traditionally, digital subtraction angiography (DSA) is the gold standard for visualization of extra-hepatic collateral arterial supply. However, catheter-directed intra-arterial computed tomographic (CT) angiography (IACTA) can be a useful adjunct to DSA to delineate arterial anatomy.

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CASE REPORT

A 51 year old Chinese man with a 20-year history of hepatitis B presented with epigastric pain. A contrast enhanced CT study at an outside institution revealed a large right hepatoma with right portal vein thrombosis and direct extension of the tumor into the intra-hepatic IVC [Figure 1]. In view of its size and vascular involvement, the patient was not suitable for systemic therapy or trans-arterial chemoembolization (TACE). He was then referred to us for suitability of Y90 radioembolization.

Pre-treatment planning was performed by obtaining a hepatic angiography using a hybrid 16-slice CT/angiography

system (Toshiba Medical Systems, Tokyo, Japan) and a Technetium-99m macro aggregated albumin (Tc-99m MAA) scan. The conventional digital subtraction angiography revealed a replaced right hepatic artery from the superior mesenteric artery. The replaced right hepatic artery, middle hepatic artery, and the right inferior phrenic artery were superselectively accessed using a 2.7F Progreat microcatheter (Terumo, Tokyo, Japan) inserted coaxially via a 4F Sim-1 catheter (Cordis, Miami, FL). Conventional DSA and intra-arterial CT angiography (IACTA) were performed for all three arteries. Arterio-portal shunting limited to the right lobe was seen during DSA of the replaced right hepatic artery and right inferior phrenic artery [Figures 2a and 3]. The bulk of the tumor was supplied mainly by the right and middle hepatic arteries. There was also a smaller contribution from the right inferior phrenic artery supplying the superior aspect of the tumor and the IVC tumor thrombus [Figure 4]. Tc-99m MAA (total of 5 mCi in 3 ml) was injected first in equal proportions into the replaced right hepatic artery, followed by the middle hepatic artery and subsequently the right inferior phrenic artery. Immediate planar and single-photon emission computed tomography (SPECT) CT images showed satisfactory tumor to normal liver ratios in the replaced right and middle hepatic artery territories. However, there was poor particulated uptake in the inferior phrenic arterial territory with no significant tracer uptake in the IVC tumor thrombus [Figure 5]. The liver-lung shunting ratios at 8.7% were within normal acceptable limits.

In view of the findings, the patient was deemed suitable for radioembolization 2 weeks later. The right inferior phrenic artery was bland embolized using 355-500 micron Contour polyvinyl alcohol particles (Boston Scientific/Target Vascular, Freemont, CA), so as to allow intra-tumor re-distribution of arterial supply from the hepatic arteries. After vascular stasis was obtained in the right inferior phrenic artery from particle embolization, the middle hepatic artery was targeted. Unfortunately, attempts at accessing the middle hepatic artery resulted in spasm requiring intra-arterial glyceryl trinitrate (GTN) infusion. Following this, 0.5 GBq of Y90 microspheres (Sirtex Medical, Lane Cove, Australia) was infused into this artery as there was good forward flow following GTN infusion. Although it was planned for Y90 to be delivered into the replaced right hepatic artery, pre-injection DSA demonstrated significant changes in flow dynamics. There was interval development of extensive arterio-portal shunting into the left liver lobe, which was not seen at the initial planning angiogram [Figure 2b]. It was deemed unsafe to proceed with Y90 injection in view of significant dose to the normal liver parenchyma of the left lobe. Immediate Bremsstrahlung study showed localization of Y90 microspheres in a small portion of the right lobe tumor, and small amount of activity in the extra-tumoral hepatic parenchyma from the arterio-portal shunting.

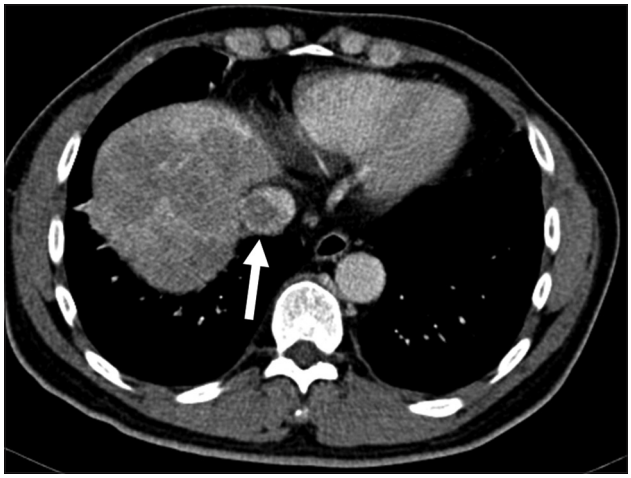

Figure 1: Portal venous phase CT showing a filling defect within the intrahepatic IVC from a tumor thrombus extending from the right lobe tumor (white arrow)

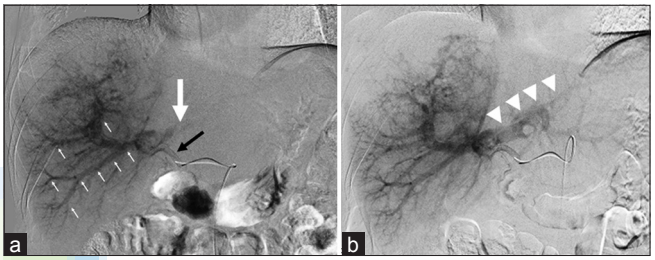

Figure 2: (a) Initial planning DSA of the replaced right hepatic artery (black arrow) demonstrating arterio-portal shunting into the right portal veins (small white arrows). No opacification of the left portal vein (large white arrow); (b) DSA of the same artery 2 weeks later demonstrating opacification of the left portal veins (white arrowheads)

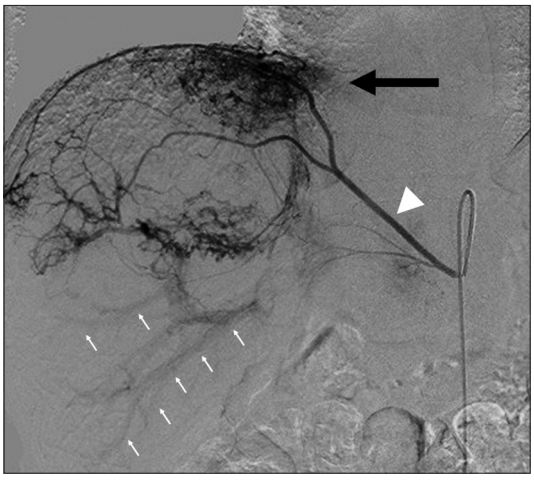

Figure 3: DSA of the right inferior phrenic artery (white arrowhead) demonstrating arterial supply to the superior aspect of the right lobe tumor, and obscuring supply to the IVC tumor thrombus due to overlap (black arrow). Arterio-portal shunting into the right portal veins is again noted (small white arrows)

As the planned administration of Y90 microspheres into the replaced right hepatic artery did not occur, the patient did

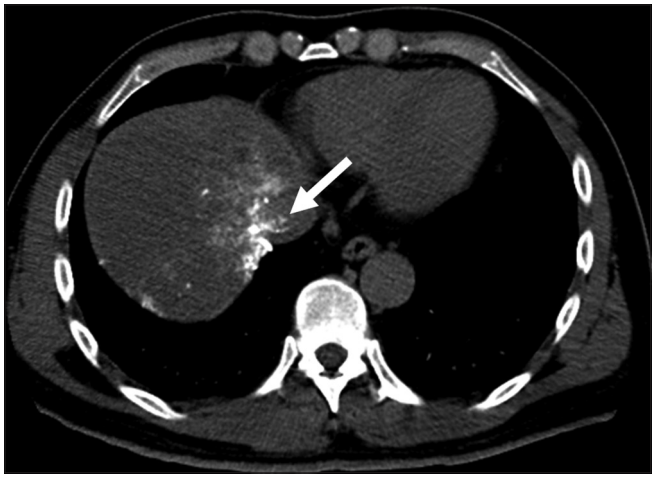

Figure 4: IACTA of the right inferior phrenic artery showing enhancement of the IVC tumor thrombus (white arrow)

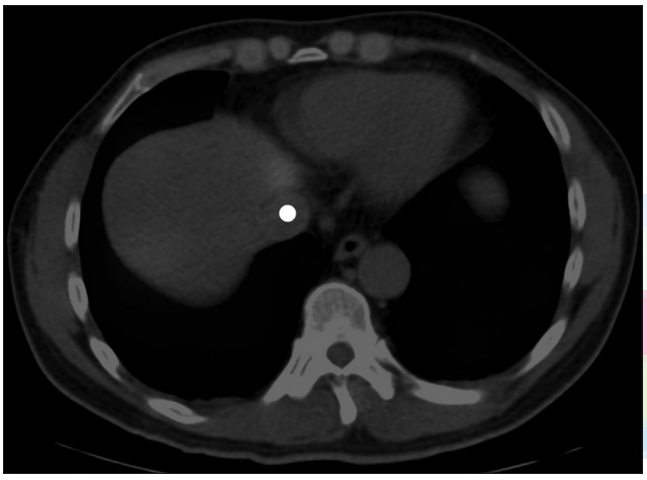

Figure 5: SPECT/CT immediately after administration of Tc-99m MAA showing no uptake by the IVC tumor thrombus (white dot)

not response to treatment from solitary administration into the middle hepatic artery. Serial follow-up CT studies showed increasing tumor burden and development of pulmonary metastases. The patient finally succumbed to his disease 7 months after radioembolization.

DISCUSSION

Treatment options are limited for patients with HCC extending into the vasculature. Trans-arterial chemoembolization (TACE) for advanced HCC with IVC invasion is considered a contraindication in many institutions.[4] However, IVC tumor thrombus is not a contraindication for Y90 radioembolization therapy.[5]

During the Tc-99m MAA planning phase for our patient, the use of DSA allowed us to globally assess arterial flow dynamics and tumor supply in 2-dimensional projection with a large field of view. The adjunctive use of IACTA provided exquisite cross-sectional arterial supply delineation, to not only confirm arterial supply to tumor, but more importantly, to exclude extra-hepatic supply to the gastrointestinal tract. Indeed, uncorrectable flow to the gastrointestinal tract (via selective coil embolization) is an absolute contraindication to Y90 therapy.[5] The combined use of DSA and IACTA may have importance in guiding elective coil embolization, calculating fractionation of Y90 doses, and obtaining better tumor coverage with the ultimate aim of improving overall survival.[1]

In our patient, selective right inferior phrenic artery DSA made visualization of the IVC tumor thrombus supply difficult due to overlap from supply to the large right lobe tumor. However, catheter-directed IACTA unequivocally demonstrated supply to the IVC tumor thrombus. Although Tc-99m MAA was administered into this artery, the lack of uptake on the SPECT/CT images implied poor particulate deposition, possibly secondary to high arterio-venous shunting. Hence, it was not unreasonable to embolize the right inferior phrenic artery using PVA particles prior to Y90 microspheres administration. The aim was to modulate intra-tumoral arterial flow dynamics, so that Y90 microspheres administered via the middle and right hepatic arteries can potentially reach the tumor originally supplied by the right inferior phrenic artery. Unfortunately, the interval development of significant tumor arterio-portal shunting into the left portal vein (and hence the left lobe parenchyma) in the 2 weeks between the Tc-99m MAA planning study and the actual administration of Y90 microspheres, as well as injury to the middle hepatic artery, resulted in suboptimal treatment.

The use of catheter-directed IACTA during Y90 radioembolization has been previously shown to significantly increase effective Y90 tumor radiation dose without clinically altering liver function or Child-Pugh class.[1] In our case, IACTA was obtained during the Tc-99m MAA planning stage rather than at the Y90 microsphere administration stage. We believe that performing IACTA earlier allows angiographic selection of suitable patients for Y90 therapy as well as planning of Y90 dosing for administration into different arteries. As this case has shown, although there was arterial enhancement of the IVC tumor thrombus on the IACTA of the right phrenic artery, the lack of Tc-99m MAA uptake meant that administration of Y90 microspheres would not be optimal for adequate therapy. Therefore, the use of IACTA at the Tc-99m MAA planning stage allowed us to decide on the most appropriate arteries to administer the Y90 microspheres into. We routinely perform planning IACTA for all patients considered for Y90 therapy so as to obtain personalized dosimetry by utilizing an artery-specific SPECT/CT partition model.[6]

We recognize that a hybrid 16-slice CT/angiography system is not widely available and therefore, routine IACTA planning may not be feasible for every institution. However, with the potential increase in the usage of Y90 therapy in treating unresectable liver tumors, we believe that a combined DSA and IACTA approach warrants further attention and future research.

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