

Utility of C-arm CT in overcoming challenges in patients undergoing Transarterial chemoembolization for hepatocellular carcinoma

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Abstract

Transarterial chemoembolization (TACE) is the well-known treatment for hepatocellular carcinoma. Multiple digital subtraction angiography (DSA) acquisitions in different projections are required to identify difficult arterial feeders. Moreover, the tell-tale tumor blush can be obscured by proximity to lung base, small size of lesion, and breathing artifacts. C-arm CT is a revolutionary advancement in the intervention radiology suite that allows acquisition of data which can be reformatted in multiple planes and volume rendered incorporating both soft tissue and vascular information like multidetector computed tomography (MDCT). These images acquired during the TACE procedure can provide critical inputs for achieving a safe and effective therapy. This case series aims to illustrate the utility of C-arm CT in solving specific problems encountered while performing TACE.

Key words: Arteriography digital subtraction; C-arm CT; cone beam computed tomography; hepatocellular carcinoma; transarterial chemoembolization

Introduction

Transarterial chemoembolization (TACE) is the well-known treatment for hepatocellular carcinoma (HCC).^[1,2] Prior to TACE, multidetector computed tomography (MDCT) can locate the lesion, map the arterial feeders, and detect extrahepatic tumor supply. Accurate superselective positioning of microcatheter ensures optimum drug delivery to the tumor and minimizes the nontarget embolization during TACE. However, tortuous arterial anatomy often mandates multiple digital subtraction

angiography (DSA) acquisitions in oblique projections to identify the arterial feeders. Moreover, the tell-tale tumor blush can be obscured by proximity to lung base, small size of the lesion, and breathing artifacts. C-arm CT is a revolutionary advancement in the intervention radiology suite that allows acquisition of data which can be reformatted in multiple planes and volume rendered incorporating both soft tissue and vascular information like MDCT. These images acquired during the TACE procedure can provide critical inputs for achieving a safe and effective therapy.

Aim

This case series aims to illustrate the utility of C-arm CT in solving specific problems encountered while performing TACE.

Materials and Methods

We included five patients (four males and one female) with average age of 58.4 years who underwent TACE for HCC.

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Technique of C-arm CT

All procedures were performed using a floor-mounted, single-plane, flat panel DSA unit (Axiom Artis Zee; Siemens, Erlangen, Germany). Using standard femoral arterial access, selective celiac and superior mesenteric artery (SMA) angiograms were done to identify putative tumor feeders. A 2.8 F microcatheter (Progreat) was then placed super selectively into the tumor feeder and TACE performed. However, when the feeder could not be clearly isolated from the adjacent branches or when multiple feeders were supplying tumor or when tumor blush could not be clearly visualized, a C-arm CT was performed. Using a power injector, 8-10 mL contrast with 30%-50% dilution was injected directly into the microcatheter at a flow rate of 2 mL/sec (proper hepatic artery) or 1 mL/sec (right hepatic artery, left hepatic artery). Acquisition delay for arterial imaging was 2-3 sec and for parenchymal imaging was 4-5 sec.^[3] Images were acquired during breath-hold with single rotation of C-arm around the patient. Three-dimensional (3D) CT like images were reconstructed and analyzed in dedicated workstation (Leonardo; Siemens, Erlangen, Germany).

Observations

The five cases included depict the use of C-arm CT to overcome various technical difficulties encountered while performing TACE for HCC. The summary of cases is presented in Table 1.

Discussion

3D DSA technology was primarily used in neuro-interventions.^[4,5] Liapi *et al.* were the first to use 3D DSA technology to delineate the vascular anatomy before TACE in two patients.^[6] As the detectability of low contrast structures was limited on 3D DSA, the angio-CT system was developed.^[7] Initial C-arm CT performed using

image intensifier system had limited spatial resolution.^[8] Recently, the use of flat panel detectors in C-arm CT has significantly improved the contrast and spatial resolution, providing CT-like images.^[9] Depicting both vascular anatomy and soft tissue is beneficial during TACE because the relationship of the tumor with its arterial supply can be clearly identified.^[7,10-12]

Principles of C-arm CT

The C-arm CT is basically a cone beam CT (CBCT). It allows volumetric data acquisition covering large anatomic area in a single rotation of the source and detector around the stationary patient. The fundamental difference between the conventional MDCT and CBCT is that CBCT acquires information using a single two-dimensional detector (flat panel detector), while MDCT uses multiple one-dimensional detectors.^[13] Flat panel detectors enable direct conversion of X-ray energy into digital signal with high resolution. The detector consists of a screen of cesium iodide (CsI) scintillator crystals arranged on a matrix of photoiodides embedded in a solid-state amorphous silicon (aSi: H) or selenium layer.^[14] The reconstruction algorithm used in CBCT is a modified Feldkamp algorithm.^[15] CBCT with flat panel detector improves the spatial resolution and decreases the radiation dose to the patient. C-arm CT has low contrast resolution as compared to MDCT because of increased scatter of X-rays. Moreover, CsI detectors have lower dynamic range and limited temporal resolution, which further decrease the contrast resolution of C-arm CT. In addition, due to the relatively long acquisition times, the technique is prone for respiratory movement artifacts.^[16,17]

Applications in TACE

Vascular imaging

C-arm CT helps to identify the vascular anatomy, multiple tumor feeders including extrahepatic supply, and tumor blush. For hypervascular lesions seen on DSA, C-arm

Table 1: Summary of the cases

Age/Sex	Clinical background	DSA findings	C-arm CT findings	Comments
60 years/female	Segment 4a hypervascular HCC	Tumor blush in segment 4a. DSA showed tumor apparently supplied by middle hepatic artery	Microcatheter in proper hepatic artery. Tumor blush in segment 4a, supplied by branch of left hepatic artery TACE performed through the correct tumor feeder	Tumor feeder confused due to overlapping arteries
55 years/male	Segment 4 HCC	DSA through proper hepatic artery showed no tumor blush (hypovascular)	Microcatheter in proper hepatic artery. Tumor blush in segment 4 supplied by branch of right hepatic artery	C-arm CT detects angiographically occult hypovascular HCC
63 years/male	Segment 8 HCC. Post-RFA. One year follow-up CT showed recurrence along margin	Right hepatic artery injection showed no tumor blush	Microcatheter in right hepatic artery. Showed tumor blush in segment 8 along with feeding artery	C-arm CT detects relatively less vascular recurrences in previously treated lesions
68 years/male	Small segment 8 HCC	DSA through right hepatic artery showed no tumor blush because of extensive respiratory movement artifacts	Microcatheter in right hepatic artery. Showed tumor blush in segment 8 along with feeding artery	Lesion in subdiaphragmatic locations (segment 7 or 8) cannot be easily detected on routine DSA
46 years/male	Diffuse HCC in the right lobe	Multiple feeders from right hepatic artery selectively catheterized and TACE performed using lipidol	C-arm CT at the end of procedure showed uniform lipidol uptake in the tumor area. No additional tumor feeders identified	Confirms the completeness of the procedure

RFA: Radiofrequency ablation

CT creates an accurate road map to the target lesion. Superselective catheterization can be achieved without resorting to multiple standard DSA views which involve incremental contrast and radiation dose. In case 1, initial DSA showed tumor blush in segment 4a with probable feeder from middle hepatic artery. However, middle hepatic artery injection showed no tumor blush. C-arm CT performed with microcatheter tip in proper hepatic artery revealed the tumor feeder arising from the left hepatic artery. This confusion was due to overlapping arteries on antero-posterior projection [Figure 1]. Accurate road map will prevent inadvertent catheterization of normal arteries and achieves optimal delivery of chemotherapeutic agent to the tumor. C-arm CT can detect feeder arteries not identified on DSA. By identifying multiple feeders, it facilitates complete treatment. Iwazawa *et al.*, in their study of 33 patients showed that C-arm CT is superior (sensitivity 96.9%) to DSA (sensitivity 77.2%) for identifying the tumor feeding arteries during TACE for HCC.^[18]

Parenchymal imaging

C-arm CT has the ability to identify parenchymal lesions that are not adequately visualized on DSA. In case 2, the segment 4 lesion was not clearly seen on DSA. C-arm CT showed the tumor blush with feeder from the right hepatic artery and TACE was performed successfully [Figure 2].

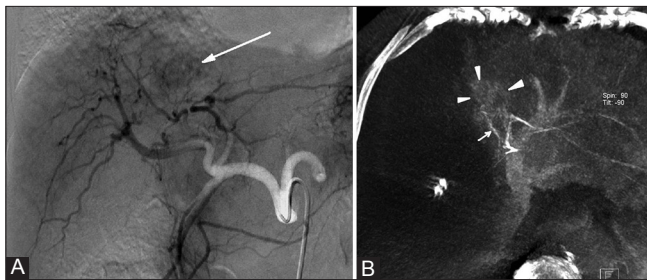


Figure 1 (A, B): A 60-year-old female with segment 4 HCC. Initial digital subtraction angiography (DSA) shows tumor blush (arrow, A). Injection through middle hepatic artery showed no tumor blush. Contrast-enhanced C-arm CT coronal maximum intensity projection (MIP) reformatted image shows enhancement of tumor (arrowheads, B) and tumor feeder from left hepatic artery (arrow, B)

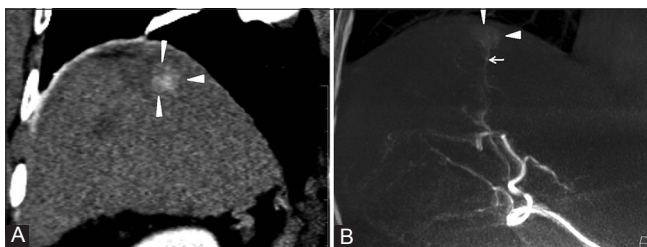


Figure 3 (A, B): A 63-year-old male presented with marginal recurrence of previously ablated segment 8 lesion. CECT coronal reformatted image shows arterial enhancement along medial margin of the previously ablated lesion (arrowheads, A). The lesion was not seen on DSA. Contrast-enhanced C-arm CT coronal MIP reformatted image shows the enhancement at recurrence site (arrowheads, B) and tumor feeder (arrow, B)

In case 3, C-arm CT convincingly showed the tumor blush along the margins of previously ablated segment 8 lesion. This was not seen on DSA [Figure 3]. Thus, hypovascular and small HCC can be confidently targeted using C-arm CT. As C-arm CT gives soft tissue information, the findings of C-arm CT and MDCT or magnetic resonance imaging (MRI) can be easily correlated and this helps both lesion targeting and follow-up comparison [Figure 4]. C-arm CT detects lesions in difficult locations like segments 7 and 8 which can be obscured on DSA due to respiratory movement artifacts [Figure 4]. C-arm CT can also be used to assess the therapeutic endpoint after TACE.^[3] Presence of areas in tumor without lipiodol accumulation or residual enhancement indicates additional hepatic or extrahepatic tumor supply. Case 5 had diffuse right lobe HCC with multiple feeders from the right hepatic artery which were selectively entered and TACE performed. At the end of procedure, we performed

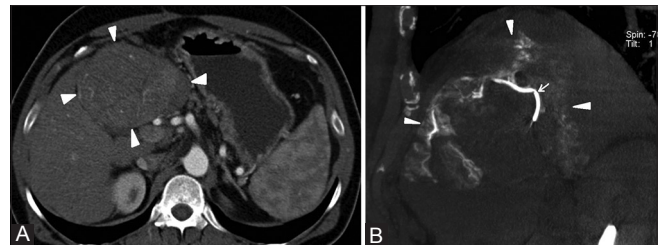


Figure 2 (A, B): A 55-year-old male presented with segment 4 HCC. Contrast-enhanced CT (CECT) axial image shows no significant enhancement of lesion (arrowheads, A). Contrast-enhanced C-arm CT coronal MIP reformatted image shows enhancement of tumor (arrowheads, B) and tumor feeder from right hepatic artery (arrow, B)

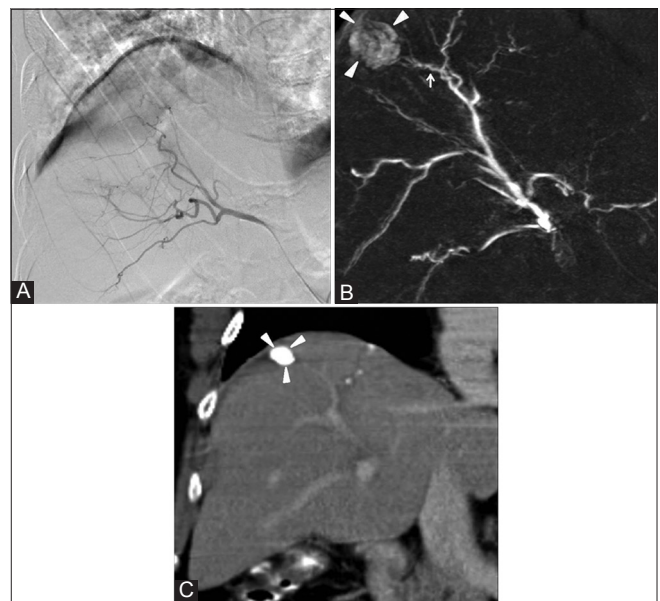


Figure 4 (A-C): A 68-year-old male with segment 8 HCC. The lesion was not seen on DSA (A). Contrast-enhanced C-arm CT coronal MIP reformatted image shows the tumor (arrowheads, B) and tumor feeder (arrow, B). TACE was performed with lipiodol and adriamycin. One year follow-up CECT coronal reformatted image shows lipiodol uptake in lesion (arrowheads, C)

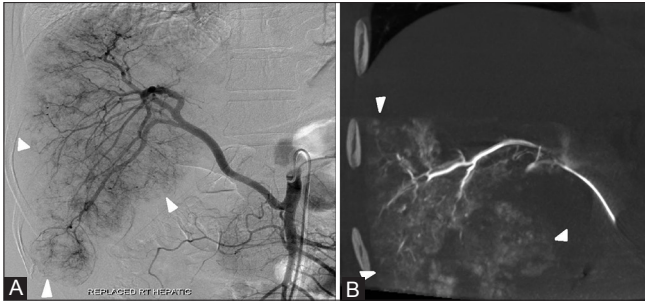


Figure 5 (A, B): A 46-year-old man with diffuse right lobe hepatocellular carcinoma. DSA shows diffuse tumor blush (arrowheads, A) supplied by multiple tumor feeders from replaced right hepatic artery, which were embolized with lipiodol and adriamycin. Post-TACE C-arm CT coronal MIP reformatted image shows uniform uptake of the lipiodol throughout the tumor area (arrowheads, B)

C-arm CT to assess the response which showed uniform lipiodol uptake in the tumor area. No abnormal blush or additional feeders were seen, thus confirming the completeness of the procedure [Figure 5].

To conclude, C-arm CT is a useful adjunct technology in interventional radiology suite that assists an interventional radiologist in performing TACE.

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