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 (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. 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.
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.[15] 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.[4] 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.[5] 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 photodiodes 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

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

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].

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
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 intervention radiology suite that assists an interventional radiologist in performing TACE.

References

1. Lo CM, Ngan H, Tso WK, Liu CL, Lam CM, Poon RT, et al. Randomized controlled trial of transarterial lipiodol chemoembolization for unresectable hepatocellular carcinoma. Hepatology 2002;35:1164-71.
2. Llovet JM, Real MI, Montana X, Planas R, Coll S, Aponte J, et al. Arterial embolisation or chemoembolisation versus symptomatic treatment in patients with unresectable Hepatocellular carcinoma: A randomised controlled trial. Lancet 2002;359:1734-9.
3. Wallace MJ, C-Arm Computed tomography for guiding hepatic vascular interventions. Tech Vasc Interv Radiol 2007;10:79-86.
4. Schueler BA, Kallmes DF, Cloft HJ. 3D cerebral angiography: Radiation dose comparison with digital subtraction angiography. Am J Neuroradiol 2005;26:1898-901.
5. Prestigiacomo CJ, Niimi Y, Setton A, Berenstein A. Three-dimensional rotational spinal angiography in the evaluation and treatment of vascular malformations. Am J Neuroradiol 2003;24:1429-35.
6. Liapi E, Hong K, Georgiades CS, Geschwind JF. Three-dimensional rotational angiography: Introduction of an adjunctive tool for successful transarterial chemoembolization. J Vasc Interv Radiol 2005;16:1241-5.
7. Hirota S, Nakao N, Yamamoto S, Kobayashi K, Maeda H, Ishikura R, et al. Cone-beam CT with flat-panel-detector digital angiography system: Early experience in abdominal interventional procedures. Cardiovasc Interv Radiol 2006;29:1034-8.
8. Feldkamp LA, Davis LC, Kress JW. Practical cone-beam algorithm. J Opt Soc Am 1984;1:612-9.
9. Ning R, Chen B, Yu R, Conover D, Tang X, Ning Y. Flat panel detector based cone-beam volume CT angiography imaging: System evaluation. IEEE Trans Med Imaging 2000;19:949-63.
10. Meyer BC, Frericks BB, Albrecht T, Wolf KJ, Wacker FK. Contrast-enhanced abdominal angiographic CT for intra-abdominal tumor embolization: A new tool for vessel and soft tissue visualization. Cardiovasc Intervent Radiol 2007;30:743-9.
11. Wallace MJ, Murthy R, Kamat P, Gupta S, Hicks ME, Ahrar K, et al. C-arm CT: Oncologic experience with hepatic arterial interventions. Chicago: Radiological Society of North America; 2006.
12. Liu DM, Salem R, Bui JT, Courtney A, Barakat O, Sergy Z, et al. Angiographic considerations in patients undergoing liver-directed therapy. J Vasc Interv Radiol 2005;16:911-35.
13. Orth RC, Wallace MJ, Kuo MD; Technology Assessment Committee of the Society of Interventional Radiology. C-arm C. C-arm Cone-beam CT: General Principles and technical considerations for use in interventional radiology. J Vasc Interv Radiol 2008;19:814-20.
14. Baba R, Konno Y, Ueda K, Ikeda S. Comparison of flat-panel detector and image intensifier detector for cone-beam CT. Comput Med Imaging Graph 2002;26:153-8.
15. Gupta R, Grasruck M, Suess C, Bartling SH, Schmidt B, Stierstorfer K, et al. Ultra-high resolution flat-panel volume CT: Fundamental principles, design architecture, and system characterization. Eur Radiol 2006;16:1191-205.
16. Siewerdsen JH, Jaffray DA. Cone beam computed tomography with a flat-panel imager: Magnitude and effects of x-ray scatter. Med Phys 2001;28:220-31.
17. Siewerdsen JH, Moseley DJ, Bakhtiar B, Richard S, Jaffray DA. The influence of antiscatter grids on soft-tissue detectability in cone-beam computed tomography with flat-panel detectors. Med Phys 2004;31:3506-20.
18. Iwazawa J, Ohue S, Mitani T, Abe H, Hashimoto N, Hamuro M, et al. Identifying feeding arteries during TACE of Hepatic Tumors: Comparison of C-arm CT and digital subtraction angiography. AJR Am J Roentgenol 2009;192:1057-63.

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