Iodized oil uptake assessment with cone-beam CT in chemoembolization of small hepatocellular carcinomas

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Abstract

AIM: To evaluate the utility of assessing iodized oil uptake with cone-beam computed tomography (CT) in transarterial chemoembolization (TACE) for small hepatocellular carcinoma (HCC).

METHODS: Cone-beam CT provided by a biplane flat-panel detector angiography suite was performed on eighteen patients (sixteen men and two women; 41-76 years; mean age, 58.9 years) directly after TACE for small HCC (26 nodules under 30 mm; mean diameter, 11.9 mm; range, 5-28 mm). The pre-procedural locations of the tumors were evaluated using triphasic multi-detector row helical computed tomography (MDCT). The tumor locations on MDCT and the iodized oil uptake by the tumors were analyzed on cone-beam CT and on spot image directly after the procedures.

RESULTS: All lesions on preprocedural MDCT were detected using iodized oil uptake in the lesions on cone-beam CT (sensitivity 100%, 26/26). Spot image depicted iodized oil uptake in 22 of the lesions (sensitivity 85%). The degree of iodized oil uptake was overestimated (9%, 2/22) or underestimated (14%, 3/22) on spot image in five nodules compared with that of cone-beam CT.

CONCLUSION: Cone-beam CT is a useful and convenient tool for assessing the iodized oil uptake of small hepatic tumors (< 3 cm) directly after TACE.

INTRODUCTION

Transarterial chemoembolization (TACE) is a regional therapeutic modality that has become an accepted treatment for unresectable hepatocellular carcinoma (HCC). Triphasic multi-detector computed tomography (MDCT) is commonly used for the detection and preprocedural localization of hypervascular HCCs greater than 1 cm in diameter. Diagnostic angiography using digital subtraction angiography (DSA) is performed before TACE in order to detect hypervascular HCCs. Occasionally, the small neoplastic foci are uncertain, and difficult to detect. Some studies have reported that the detection rate of small HCCs, less than 3 cm, in DSA was about 70%, and other studies showed higher sensitivity in nodule detection in helical biphasic CT than in DSA. This discrepancy can make it difficult to determine whether or not the same nodules exist on MDCT in cases of small tumor nodules.
local recurrence[7-9], however, a method for evaluating this immediately after TACE, is to take a spot image Follow- up unenhanced CT is usually performed within 1 mo after TACE, but it is sometimes difficult to determine whether there is washout of iodized oil uptake or initial failure of iodized oil uptake when there is partial iodized oil uptake in a lesion on the first follow-up CT. The exact method for comparing iodized oil retention in hypervascular nodules on preprocedural MDCT is to check the postprocedural CT directly after TACE and for this the patient must be transported from the angiography suite to the nearest CT scanner.

Cone-beam CT is a new technology provided by the combined angiography/CT suite that uses flat-panel detector (FD) technology. It provides images similar to those of CT and is able to obtain 3D reconstructions such as multiplanar reformat (MPR), maximum intensity projection (MIP), and 3D volume rendering (VR) with these data sets.

The purpose of this study was to evaluate the clinical value of cone-beam CT in the assessment of iodized oil uptake in TACE for small HCCs.

**MATERIALS AND METHODS**

**Patients**

From March 2006 to June 2006, eighteen patients (sixteen males and two females; 41-76 years; mean age, 58 years) with small HCCs (26 nodules; mean diameter 11.9 mm; range, 5-28 mm), underwent cone-beam CT and TACE consecutively. All patients had underlying liver cirrhosis. The diagnosis of HCC was made clinically in these patients by using typical imaging findings on MDCT and iodized oil uptake when there is partial iodized oil uptake or initial failure of iodized oil uptake in the nodules more clearly than spot image.

Cone-beam CT acquisition was obtained using the following parameters: 10-s rotation; 0.4° increment; 1024 × 793 matrix in projections at zoom 0 after resampling; 217° total angle; and 11°/s, 27 frames/s, system dose 0.36 μGy/pulse, total 273 projections. The image reconstruction was performed on a commercially available dedicated workstation (X-Leonardo with DynaCT; Siemens Medical Solutions). The volume dataset was displayed on the monitor in the MPR.

Cone-beam CT was successfully completed in all study patients. It only took about 5 min to obtain MPR images. Cone-beam CT visualized the iodized oil uptake in all the nodules (26/26, sensitivity 100%), but spot image only visualized iodized oil uptake in 22 of the lesions (sensitivity 85%) (Figures 1 and 2).

**RESULTS**

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#### Degree of iodized oil uptake in tumors

The degree of iodized oil uptake was somewhat different in the two modalities (Table 1). Cone-beam CT depicted iodized oil uptake in the nodules more clearly than spot image. Two nodules were not seen in spot image but were clearly evaluated with cone-beam CT. There was discordance between the two modalities in 5 nodules and

| Degree   | Spot image | Cone-beam CT |
|----------|------------|--------------|
| Excellent| 11         | 16           |
| Good     | 8          | 7            |
| Poor     | 3          | 3            |
| Total    | 22         | 26           |

Discordance between the two modalities—5 nodules [over-: 9% (2/22), underestimated: 14% (3/22) in spot image]. CT: Computed tomography.
iodized oil uptake was over-estimated (9%, 2/22) or underestimated (14%, 3/22) in spot image compared with cone-beam CT. The iodized oil uptake in 4 nodules was not seen in spot image, two nodules were less than 1 cm, one was between 1 cm and 2 cm, and one was over 2 cm. The discordance between the two modalities occurred in nodules less than 2 cm (Table 2).

Nodules with atypical enhancement patterns in MDCT
Three nodules showed atypical enhancement patterns in MDCT, and additional dynamic magnetic resonance imaging (MRI) was performed for one nodule (Figure 2). Their feeders were uncertain on selective right or left hepatic arteriography, but were detected with cone-beam CTHA. Enhancement patterns and iodized oil uptake in the nodules are shown in Table 3.

DISCUSSION
Several treatment options for small HCCs have been introduced for patients who are not surgical candidates. These options include TACE, percutaneous ethanol injection (PEI), radiofrequency ablation (RFA), microwave coagulation therapy (MCT), laser thermal ablation (LTA), and combination therapy\cite{10,11}. Among them, TACE is widely performed, because it is minimally invasive, repeatable, and more effective in combination with other treatments\cite{10-15}.

TACE was found to be as effective as hepatic resection for early stage tumors when iodized oil was compactly retained within the tumor\cite{8}. Iodized oil uptake pattern can be a prognostic index\cite{7}. Various studies have suggested that iodized oil uptake in a tumor can correlate well with hepatic necrosis, and compact iodized oil uptake on unenhanced CT may represent necrosis\cite{16,17}. Takayasu et al\cite{16} reported that the highest degree of necrosis usually occurs immediately after TACE and the regrowth of viable cancer cells will occur later if complete necrosis of the tumor was not achieved. At this
point, compact iodized oil uptake by the tumor directly after the procedure prevents regrowth of tumors, but to confirm this, only spot image is usually acquired. If the tumor is large enough to appear on spot images, it is easy to determine the degree of iodized oil uptake, but if the tumor is small, especially less than 2 cm, the degree of iodized oil uptake is incorrectly determined, which can cause tumor regrowth. It is also impossible to refuse chemoantithetical agents directly if there is partial iodized oil uptake in a lesion on the first follow-up CT.

Cone-beam CT was first used in neuroendovascular procedures, and the image quality is sufficient to make a diagnosis when a complication is suspected. In the era of assessing the degree of iodized oil uptake, cone-beam CT is also a convenient tool during and after TACE and clearly correlates with MDCT. If cone-beam CT images shows non-compact iodized oil uptake, immediate re-intervention can be achieved. The disadvantages of this CT-like image are low temporal resolution and a small field of view, however, it is sufficient to locate lesions previously diagnosed on MDCT.

Takayasu et al reported “targeted transarterial oily chemoembolization” which is a similar method to ours, but these authors used a unified helical CT and angiography system. Our system is only a DSA machine without a helical CT system and has more simple structures.

The radiation dose from cone-beam CT was not measured, however, Hirota et al measured the radiation dose of cone-beam CT with a flat-panel-detector digital angiography system (similar system with ours) and single helical CT using a cylindrical phantom model of CT dose index with a dosimeter. They reported that the radiation dose by cone-beam CT was less than that of single helical CT. In addition, the radiation dose from cone-beam CT can be calculated via a pre-set radiation dose (0.36 μGy/pulse) and total fluoro time (7.5 pulse/s, 10 s). Compared with nonenhanced MDCT for TACE follow-up, the calculated radiation dose of cone-beam CT is low.

Cone-beam CTHA placing the microcatheter in the nearest arteries was performed in only three nodules in this study. Another study also reported this method, and this technique is very useful to confirm a perfusion area in the artery. Although a small number of cases were included in this study, this method is a very useful and time-saving technique in TACE and other interventional procedures, especially for small lesions.
In conclusion, cone-beam CT is a useful and convenient tool for assessing the iodized oil uptake by small hepatic tumors (< 3 cm) directly after TACE. In addition, in cases with suspected small HCC nodules without typical enhancement patterns on CT, cone-beam CTHA will be very useful, however, further study is required.

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