CLINICAL STUDY

Diagnostic Accuracy of Split-Bolus Single-Phase Contrast-Enhanced Cone-Beam CT for the Detection of Liver Tumors before Transarterial Chemoembolization

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ABSTRACT

Purpose: To evaluate detectability of hepatocellular carcinoma (HCC) using split-bolus cone-beam CT in intraindividual comparison between cone-beam CT and contrast-enhanced MR imaging.

Materials and Methods: In a retrospective, single-center study, 28 patients with 85 HCC tumors were treated with transarterial chemoembolization between May 2015 and June 2016. All patients underwent arterial and hepatobiliary phase (HBP) MR imaging within 1 month before transarterial chemoembolization. Cone-beam CT images were acquired using a split-bolus contrast injection with 2 contrast injections and 1 cone-beam CT acquisition. Statistical analyses included Friedman 2-way analysis, Kendall coefficient of concordance, and Wilcoxon test. Tumor detectability was scored using a 5-point system (1 = best; 5 = worst) by 2 independent readers resulting in 170 evaluated tumors. Quantitative analysis included signal-to-noise and contrast-to-noise ratio and contrast measurements. P values $< .05$ were considered significant.

Results: Better tumor detection was provided with split-bolus cone-beam CT (2.91/2.73) and HBP MR imaging (2.93/2.21) compared with arterial MR imaging (3.72/3.05; $P < .001$) without statistical difference between cone-beam CT and HBP MR imaging in terms of detectability ($P = .154$) and sensitivity for hypervascularized tumors. More tumors were identified on cone-beam CT (n = 121/170) than on arterial MR imaging (n = 94/170). Average contrast-to-noise ratio values of arterial and HBP MR imaging were higher than for cone-beam CT (7.79, 8.58, 4.43), whereas contrast values were higher for cone-beam CT than for MR imaging (0.11, 0.13, 0.97).

Conclusions: Split-bolus cone-beam CT showed excellent detectability of HCC. Sensitivity is comparable to HBP MR imaging and better than arterial phase MR imaging.

ABBREVIATIONS

CNR = contrast-to-noise ratio, DSA = digital subtraction angiography, FOV = field of view, HCC = hepatocellular carcinoma, HBP = hepatobiliary phase, SNR = signal-to-noise ratio

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Although transarterial chemoembolization is a technically well-established palliative treatment option in patients with hepatocellular carcinoma (HCC) and metastatic liver disease (1), tumor visualization as well as intraprocedural detection of tumor feeding arteries can be difficult. In a diagnostic setting, different techniques are available for sufficient HCC detection. Ladd et al (2) showed that the sensitivity for HCC detection was 51.5% for magnetic resonance (MR) imaging, which was significantly higher than for multidetector computed tomography (CT), 49.8%, in 41 patients with 116 tumors receiving an orthotopic liver transplant. In the same study, digital subtraction angiography (DSA) showed a sensitivity of 41.7%. Moreover, there is some evidence that sensitivity for detection of gadoxetic acid–enhanced MR imaging is higher than for contrast-enhanced CT (3–7) and for contrast-enhanced MR imaging using extracellular contrast agents (8,9).

In an intraprocedural setting, this issue has been addressed with the advent of the dual-phase cone-beam CT protocol, which was shown to detect liver tumors with substantially better diagnostic accuracy than DSA alone (93.4% for dual-phase cone-beam CT vs 45.9% for DSA) (10). In addition, initial evidence suggests potential benefits of dual-phase cone-beam CT regarding tumor detectability compared with conventional multiphasic gadolinium-enhanced MR imaging and single-phase cone-beam CT (10,11). Moreover, dual-phase cone-beam CT is increasingly used to immediately assess and predict tumor response, whereas additional imaging biomarkers are currently being developed to better evaluate treatment success in the intraprocedural setting (12).

The application of a contrast agent as a split bolus in 2 fractions to assess 2 contrast phases in a single image acquisition has been described for multidetector CT (13–16). This study compares a split-bolus injection protocol for cone-beam CT with contrast-enhanced MR imaging. The purpose of this clinical study was to validate a split-bolus contrast injection technique combined with a single cone-beam CT acquisition and to compare the detectability of arterially hypervascular liver tumors on split-bolus cone-beam CT with contrast-enhanced (gadoxetic acid [Primovist; Bayer AG, Leverkusen, Germany]) arterial phase and hepatobiliary phase (HBP) MR imaging.

MATERIALS AND METHODS

This institutional review board–approved, retrospective, single-center, single-arm study included 28 consecutive patients who were treated using cone-beam CT during transarterial chemoembolization of 85 HCC tumors between May 2015 and June 2016. Written informed consent was obtained from patients. Diagnosis of HCC was verified using imaging features such as contrast enhancement patterns and tumor growth at follow-up (17–23). Patients with preserved liver function and mild stage liver disease (Child-Pugh class A and B) were included in this exploratory study (**Table 1**). Clinical characteristics of patients are summarized in **Table 2**.

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
HCC verified by imaging features and tumor growth at follow-up (17–23)	Severe or increasing liver dysfunction (Child-Pugh class C)
Patient eligible for transarterial chemoembolization	Relative contraindications
Preserved liver function (Child-Pugh class A and B)	Bacterial infection
Cone-beam CT performed with split-bolus protocol	INR > 1.9, prothrombin time < 50%, platelets < 50,000/μL, aPTT < 50 s
	Liver perfusion deficiency
	Portal vein invasion
	Extrahepatic tumor
	ECOG performance status > 0

aPTT = activated partial thromboplastin time; ECOG = Eastern Cooperative Oncology Group; HCC = hepatocellular carcinoma; INR = international normalized ratio.

MR Imaging

Each patient underwent contrast-enhanced MR imaging with a liver-specific contrast agent (Primovist 1 mL/10 kg body weight) within 1 month before transarterial chemoembolization in a 1.5-T MR imaging unit (Magnetom Avanto; Siemens AG Medical Solutions, Forchheim, Germany). Dynamic contrast imaging was performed with a T1-weighted volumetric interpolated breath-hold examination sequence (repetition time = 4.6 ms, echo time = 2.2 ms, flip angle = 9°, field of view (FOV) = 320 × 195 mm, pixel resolution = 1.25 × 1.25 mm, slice = 3 mm, number of signals averaged = 1) after a predefined delay of 15 seconds for the arterial phase and 20 minutes for the HPB.

Transarterial Chemoembolization Protocol

All treatments were performed by board-certified radiologists (B.G., G.W., F.S., D.S., all with > 10 years of experience, and D.G., with 1 year of experience after certification). Femoral access was obtained using the Seldinger technique. A celiac angiogram was acquired with a 5-F Cobra (Radifocus; Terumo Europe NV, Leuven, Belgium) or a 5-F SOS Omni Selective catheter (Soft-Vu; Angiodynamics, Latham, New York). After placing a microcatheter (Cantata 2.5 F or MicroFerret-18 3 F; Cook Medical, Bjaeverskov, Denmark) in the hepatic artery proper, cone-beam CT was performed (image acquisition details described in the following section). Further DSA runs depicted hepatic artery anatomy, patency of the portal vein, and the tumor. After selective positioning of the microcatheter in the feeding arteries, conventional transarterial chemoembolization using a Lipiodol (Guerbet, Villepinte, France) mixture with 50 mg of doxorubicin and