CLINICAL STUDY

Sensitivity and Reproducibility of Automated Feeding Artery Detection Software during Transarterial Chemoembolization of Hepatocellular Carcinoma

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ABSTRACT

Purpose: To evaluate the performance of automated feeder detection (AFD) software (EmboGuide; Philips Healthcare, Best, The Netherlands) on hepatocellular carcinoma (HCC) tumors during transarterial chemoembolization.

Materials and Methods: Forty-four first-time transarterial chemoembolization patients (37 men; mean age, 62 ± 11 years) were enrolled between May 2012 and July 2013. A total of 86 HCC lesions were treated (2.0 ± 1.4 lesions per patient; 27.6 ± 15.9 mm maximum diameter). One hundred forty-seven feeding arteries were found with digital subtraction angiography (DSA), cone-beam computed tomography (CT), and AFD software with the option of manual adjustment (MA). Three independent interventional radiologists analyzed the cone-beam CT images retrospectively with and without AFD and MA. Compared with the number of treated vessels, the number of true positives, false positives, false negatives, sensitivity, and interreader agreement were determined using clustered binary data analysis.

Results: Cone-beam CT enabled detection of 100 ± 3.5 feeding arteries (70% sensitivity) with 68.6% agreement among readers. AFD software significantly improved detection to 127±0.6 feeding arteries (86% sensitivity, $P = .008$) with 99.7% reader agreement and reduced the number of false negatives from an average of 47 ± 3.5 to 20 ± 0.6 ($P = .008$). MA of the AFD results produced similar feeding artery detection rates (127 ± 5.1, 86% sensitivity, $P = .8$), with lower interreader agreement (91.6%) and slightly fewer false positives (16 ± 0.0 to 14 ± 2.5, $P = .4$).

Conclusions: AFD software significantly improved feeding artery detection rates during transarterial chemoembolization of HCC lesions with better user reproducibility compared with cone-beam CT alone. In conjunction with DSA, AFD enables maximum feeding artery detection in this setting.

ABBREVIATIONS

AFD = automated feeder detection, DSA = digital subtraction angiography, HCC = hepatocellular carcinoma, MA = manual adjustment

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INTRODUCTION

The success of transarterial chemoembolization procedures for the treatment of hepatocellular carcinoma (HCC) depends on identifying the feeding arteries to maximize the benefit of chemotherapy and deliver the embolic agent into the tumor, thereby inducing tumor necrosis with minimal toxicity to healthy liver tissue (1). Feeding arteries can be detected with modern C-arm systems that accommodate 2-dimensional (2D) digital subtraction angiography (DSA), 3-dimensional (3D) cone-beam computed tomography (CT), and automated feeder detection (AFD) software (2). The use of AFD software has been validated by 3 independent commercially available software programs: Syngo Embolization Guidance (Siemens Healthineers, Forchheim, Germany), FlightPlan (GE Healthcare, Waukesha, Wisconsin) and EmboGuide (Philips Healthcare, Best, The Netherlands). The published results of the software are generally similar (**Table 1**). AFD software significantly improved feeding artery detection sensitivity (38%–72% vs. 80%–97%) and positive predictive value (58–95% vs. 83%–99%) compared to DSA (3–7). Compared to the use of native cone-beam CT images, Deschamps et al showed that AFD software increased sensitivity from 73% to 93% and improved interreader agreement from 62% to 82%, while positive predictive value remained at 91% in patients with HCC or neuroendocrine tumors (4). In a recent study, Ronot et al simulated transarterial chemoembolization procedures for various tumor types. No reference artery was established for feeding arteries, but they found that manual adjustment (MA) of the AFD results reduced sensitivity from 91% to 83% and interreader agreement from 92% to 80%, although positive predictive value increased from 83% to 91% (8). The aim of our study was to evaluate the benefit of AFD on cone-beam CT analyses in patients with HCC who underwent a first-time transarterial chemoembolization procedure in terms of sensitivity, positive predictive value, and interreader agreement.

MATERIAL AND METHODS

Study Design

This single-center study prospectively included all patients who underwent a first-time transarterial chemoembolization treatment for HCC from May 2012 to July 2013. The study period was divided into 2 parts:

i. Reference Data Acquisition: The treating interventional radiologists (M.C. and H.K.) identified a reference set of feeding arteries from the patient data using a combination of DSA (Allura Xper FD20, Philips Healthcare,), dual-phase cone-beam CT (XperCT, Philips Healthcare), and AFD software with MA (EmboGuide).

ii. Reader Data Analysis: Three interventional radiologists (W.P., T.S., and G.M.) from different institutions were then asked to identify the feeding arteries for each of the tumors based on cone-beam CT data alone (CBCT), then with the AFD software (cone-beam CT + AFD), and finally with any MAs of the AFD data (cone-beam CT + AFD + MA).

Patient Population

Patients included in this study were diagnosed with HCC according to the guidelines of the American Association for the Study of Liver Diseases (9). The decision to perform a first transarterial chemoembolization treatment was made by consensus of a multidisciplinary clinical team. The study was approved by the local Medical Ethics Committee (Comité de Protection des Personnes) with waiver of written consent.

A total of 63 consecutive patients underwent transarterial chemoembolization treatment for HCC between May 2012 and July 2013. Nineteen patients were excluded due to motion artifacts on cone-beam CT (n = 11), infiltrative HCC (n = 2), previous transarterial chemoembolization treatment (n = 1), tumors and/or feeding arteries outside the field of view (n = 2), insufficient contrast injection for feeding artery detection (n = 2), and data mismatch between the reference feeding artery set and external readers' review (n = 1). The remaining 44 patients (37 men; mean age, 62±11 years) had a total of 86 HCC lesions (1–7 lesions/patient) measuring 27.6±15.9 mm, all of which were evaluated for feeding arteries. All detectable tumors evaluated were treated.

DSA and Cone-Beam CT Image Acquisition

M.C. and H.K. (with 15 and 2 years of experience, respectively) performed all transarterial chemoembolization procedures under local anesthesia. Imaging was acquired during a hepatic arteriography through femoral access. 2D DSA images were collected using 15 ml of iodinated contrast media (Visipaque, 270 mgI/mL, Iodixanol, GE Healthcare, Marlborough, Massachusetts) at a flow rate of 3 ml/s and a frame rate of 2 images/s (**Fig 1a**). DP- cone-beam CT consisted of 2 sequential cone-beam CT acquisitions during a forward and backward rotation of the gantry to visualize contrast-enhanced arterial vasculature and parenchymal tumor enhancement, respectively. Each cone-beam CT scan required a 240° rotation of the gantry and the acquisition of 310 projection images in 5.2 seconds (X-ray parameters: 120 kV, 200–300 mAs; FOV: 25x25x19 cm; matrix size: 384x384x296; pixel binning: 4x4). The arterial phase cone-beam CT was acquired 5 seconds after the start of contrast injection (20 mL Visipaque, 2 mL/s), while the delayed phase cone-beam CT followed 7 seconds after the end of the first scan (**Fig 1b**). The 3D reconstructed images were immediately accessible to the operators on a workstation (XtraVision Interventional Workstation 9.0, Philips Healthcare) equipped with the AFD software and the ability to extract anonymized images for subsequent analysis.

AFD

The AFD software procedure involved 3 steps: (1) manual identification and segmentation of HCC tumors, (2) manual