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ORIGINAL ARTICLE

Combined early dynamic ^{18}F-FDG PET/CT and conventional whole-body ^{18}F-FDG PET/CT provide one-stop imaging for detecting hepatocellular carcinoma

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Summary
Background and objective: It is widely accepted that conventional ^{18}F-FDG PET/CT (whole-body static ^{18}F-FDG PET/CT, WB ^{18}F-FDG PET/CT) has a low detection rate for hepatocellular carcinoma (HCC). We prospectively assessed the role of early dynamic ^{18}F-FDG PET/CT (ED ^{18}F-FDG PET/CT) and WB ^{18}F-FDG PET/CT in detecting HCC, and we quantified the added value of ED ^{18}F-FDG PET/CT to WB ^{18}F-FDG PET/CT.
Methods: Twenty-two patients with 37 HCC tumors (HCCs) who underwent both a liver ED ^{18}F-FDG PET/CT (performed simultaneously with a 5.5 MBq/kg ^{18}F-FDG bolus injection and continued for 240 s) and a WB ^{18}F-FDG PET/CT were enrolled in the study.
Results: The WB ^{18}F-FDG PET/CT and ED ^{18}F-FDG PET/CT scans were positive in 56.7% (21/37) and 78.4% (29/37) HCCs, respectively ($P < 0.05$). ED ^{18}F-FDG PET/CT in conjunction with WB ^{18}F-FDG PET/CT (one-stop ^{18}F-FDG PET/CT) improved the positive detection rates of WB and ED ^{18}F-FDG PET/CT alone from 56.7% and 78.4% to 91.9% (34/37) ($P < 0.001$ and $P > 0.05$, respectively).
Conclusion: One-stop ^{18}F-FDG PET/CT appears to be useful to improve WB ^{18}F-FDG PET/CT for HCC detection.

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Hepatocellular carcinoma (HCC) is the fifth most common cancer and the third leading cause of cancer death globally [1]. The cancer burden is significant in developing countries, including in China. According to a 2009 report from the National Central Cancer Registry of China, HCC was the fourth most prevalent cancer, with a crude incidence of 28.71/100,000, and the second most frequent cause of cancer mortality, with a crude mortality of 26.04/100,000 [2].

Early detection of HCC is critical to providing radical cures, which improve patient survival and quality of life. Although conventional ^{18}F-FDG PET/CT (i.e., whole-body static ^{18}F-FDG PET/CT, WB ^{18}F-FDG PET/CT), performed approximately 60 min after an intravenous injection of ^{18}F-FDG, is invaluable in the majority of malignant tumors (and particularly in suspected metastases), it is commonly accepted that WB ^{18}F-FDG PET/CT has low detection rate for HCC [3—7].

As a diagnostic supplement for WB ^{18}F-FDG PET/CT, PET/CT with other radiopharmaceutical (^{11}C-choline, ^{11}C-acetate, ^{18}F-choline, etc.) have played an important role in the clinical management of HCC patients [5,8—11]. However, other radiopharmaceuticals are not easily available in PET centers of small- and medium-scaled hospitals in developing countries.

Early dynamic ^{18}F-FDG PET/CT (ED ^{18}F-FDG PET/CT) can be defined as radionuclide blood perfusion imaging beginning with an ^{18}F-FDG bolus injection, and it might, similar to dynamic CT and MRI perfusion imaging, be a promising method for detecting and characterizing highly vascular tumors (such as HCC [12]). It can be routinely combined with WB ^{18}F-FDG PET/CT (metabolism imaging) because there is no need for an additional dose of ^{18}F-FDG or other radiopharmaceuticals. Thus, one-stop ^{18}F-FDG PET/CT (both perfusion and metabolic imaging) could be easily available in a single examination, which could expand the application of ^{18}F-FDG PET/CT. Recently, a pilot study by Bernstine et al. [12] demonstrated the feasibility of using ED ^{18}F-FDG PET/CT to distinguish and characterize HCCs, and Schierz et al. [13] further improved the ED^{18}F-FDG PET/CT protocol. We performed this study to assess the clinical role of ED ^{18}F-FDG PET/CT for HCC detection and to quantify the value of adding ED ^{18}F-FDG PET/CT to WB ^{18}F-FDG PET/CT.

Materials and methods

Patients

This study was approved by the Institutional Review Board of the Nanfang Hospital at the Southern Medical University. All of the patients provided their written informed consent prior to their participation in the study.

From April 2013 to January 2014, a total of 22 patients (19 men and 3 women) with 37 HCCs were assessed in this study, including 19 newly diagnosed cases with 31 HCCs and 3 recurrent cases with 6 HCCs. Eleven patients had a single lesion, 7 patients had two lesions, and 4 patients had three lesions. Of the 22 patients, the mean age was 50.0 ± 12.7 years old (ranging from 29 to 72 years). Fifteen patients were infected with the hepatitis B virus (HBV), 1 patient was infected with the hepatitis C virus (HCV), and 14 patients suffered from liver cirrhosis. Confirmation of HCC was based on histopathological diagnoses in 13 patients, including surgery in 11 and liver biopsy in 2. The other patients were diagnosed using the American Association for the Study of Liver Diseases (AASLD) criteria [4,5,14,15]. Among the 22 patients, 6 patients were within Milan criteria.

^{18}F-FDG PET/CT

The ^{18}F was produced in a PET trace cyclotron (GE Healthcare, Waukesha, WI, USA). ^{18}F-FDG was automatically synthesized in a chemical synthesis module (Beijing PET Biotechnology Co., Ltd., China) with radiochemical purity of > 95%. All of the examinations were performed on a Biography mCT PET/CT Scanner (Siemens AG, Munich, Germany).

ED ^{18}F-FDG PET/CT

After the patient fasted for more than 6 h and the blood glucose was verified (5.3 ± 0.6 mmol/L, ranging from 4.1 to 6.2 mmol/L), a low-dose CT scan (120 kV, 50 mA) was performed, including a single bed position and centering on the liver. Then an ED ^{18}F-FDG PET scan (continuing for 240 s) and the ^{18}F-FDG bolus were simultaneously performed. ^{18}F-FDG (5.5 MBq/kg) was manually administered in a 2-mL bolus in 0.9% saline as soon as possible and was followed by 20-mL of 0.9% saline as a 2-mL/s washout.

WB ^{18}F-FDG PET/CT

A routine CT scan (120 kV, 100 mA) was performed at 61.4 ± 5.6 min (ranging from 51 to 73 min) after the ^{18}F-FDG bolus, which included 6—8 bed positions from the vertex of the skull to the proximal thigh, and then a PET scan was performed for 1.5 min in each bed position.

Image reconstruction and fusion

CT images were reconstructed onto a 512 × 512 matrix by a filtered back projection algorithm. PET images were reconstructed onto a 200 × 200 pixel matrix by a standard iterative algorithm (ordered subset expectation maximization), using the CT data for attenuation correction. The ED ^{18}F-FDG PET data were reconstructed as 4 frames per 15 s interval, followed by 3 frames per 60 s interval [13]. The CT image reconstruction thicknesses was 3.0 mm, and the PET and CT images were individually transferred to Syngo MMWP workstations to display the frame-on-frame fusion images, using TrueD software (Siemens). For semiquantitative analysis, the maximum standardized uptake value (SUV_{max}) of ^{18}F-FDG was measured from PET images by placing regions of interest (ROIs) that had focal lesions with increased FDG accumulation. In those lesions with imperceptible FDG uptake, ROIs were drawn relative to the conventional imaging findings. To compare HCC tumors to the surrounding tumor-free liver tissue, the respective ROIs were drawn in tumor-free liver tissue, and all ROIs excluded blood vessels. We also measured the SUV_{max} of the celiac trunk and portal vein.