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Value of ^{18}F-FDG PET/CT in the diagnosis of primary gastric cancer via stomach distension

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ABSTRACT

Objective: To clarify the usefulness of ^{18}F-FDG PET/CT for detecting primary gastric cancer via gastric distention using a mixture of milk and Diatrizoate Meglumine.
Materials and methods: A total of 68 patients (male: 47, female: 21; age: 41–87 years) suspected of gastric carcinoma underwent ^{18}F-FDG PET/CT imaging. After whole-body PET/CT imaging in a fasting state, the patients drank a measured amount of milk with Diatrizoate Meglumine. Local gastric district PET/CT imaging was performed 30 min later. The imaging was analyzed by semi-quantitative analysis, standardized uptake value (SUV) of the primary tumor was measured in a region of interest. The diagnosis results were confirmed by gastroscopy, pathology, and follow-up results.
Results: Of the 68 patients, 56 malignant gastric neoplasm patients (male: 37, female: 19) were conformed. The sensitivity, specificity, positive predictive value and negative predictive value of fasting whole-body PET/CT imaging for a primary malignant tumor were 92.9%, 75.0%, 94.5%, and 69.0%, respectively. The values for distension with a mixture of milk and Diatrizoate Meglumine were 91.1%, 91.7%, 98.1%, and 68.8%, respectively. The area under the curve was 0.919 ± 0.033 and 0.883 ± 0.066 for the diagnosis of gastric cancer with SUV_{max} in a fasting state and after intake of mixture respectively, the differences were not statistically significant ($P = 0.359$). Using gastric distension with a mixture of milk and Diatrizoate Meglumine, the mean ratio of the lesion's SUV_{max} to the adjacent gastric wall SUV_{max} increased significantly from 3.30 ± 3.05 to 13.50 ± 15.05, which was statistically significant ($P < 0.001$).
Conclusions: ^{18}F-FDG PET/CT imaging is highly accurate for the diagnosis of primary gastric carcinoma. Gastric distention can display the lesions more clearly, however, it cannot significantly improve diagnostic accuracy.

1. Introduction

Gastric cancer is the world's fourth most common malignancy, and its mortality rate is second to lung cancer. Each year, 1 million patients are diagnosed with gastric cancer worldwide, the ratio of male to female is about 2:1. Gastric cancer is responsible for approximately 850,000 deaths each year, accounting for 12% of all cancer deaths [1]. The disease incidence of gastric cancer in china is 4–8 times that of the United States and Europe, and nearly 70,000 patients die from gastric cancer each year in China. In clinical and scientific research, PET has been used extensively for the primary diagnosis of gastric cancer and preoperative staging, and to guide surgery [2,3]. Furthermore PET is used for monitoring gastric cancer recurrence and treatment efficacy [4–6]. Due to the digestive physiological motility and physiological uptake of ^{18}F-FDG, the accuracy of ^{18}F-FDG PET/CT in early gastric cancer diagnosis is inadequate. In order to improve the accuracy of the diagnosis of gastric cancer for ^{18}F-FDG PET (PET/CT), a number of studies regarding stomach distension have been conducted, their aim was to improve the diagnostic accuracy [7–11]. Methods employed have included ingestion of water, foaming agents, food, or milk before imaging. This study comprised the scanning of 68 cases of gastric disease with the use of a mixture of milk and Diatrizoate Meglumine with ^{18}F-FDG PET/CT to explore its diagnostic value for primary gastric cancer.

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2. Materials and methods

2.1. Patients

The ethics committee of our institution approved this study and written informed consent was obtained from all patients after detailed explanations. From June 2010 through June 2012, 78 patients with gastric disease were examined by ^{18}F-FDG PET/CT imaging at our hospital. For inclusion in the study, the following patient characteristics were required: gastric lesion confirmed by gastroscopy within the past two weeks (benign, malignant potential or malignant); having no special treatment during the time, which included surgery by gastroscopy, radiotherapy and chemotherapy; and gastroscopy or surgical treatment was performed within two weeks following a PET/CT scan. In addition, malignant disease needed to be surgically confirmed and have pathological staging. Non-malignant lesions such as stomach ulcers were required to resolve after treatment with endoscopic confirmation. Gastritis or other non-malignant disease should not progress in clinical symptomatology after more than six months of follow-up.

Case exclusion criteria were: no final diagnosis; incomplete follow-up or other relevant information; treatment had begun before the PET scan; allergic to milk or iodine; or contraindicated because of serious health status, Such as the patient cannot intake a certain amount of milk into the stomach. After review, five patients were excluded for no pathological findings, two cases were lost to follow-up, two cases of PET/CT images were unclear with much artifact due to technical problems in PET/CT equipment one day, and one patient began chemotherapy before the PET scan.

2.2. PET/CT protocol

Our hospital used Discovery ST 16 PET/CT (GE, US, 2005), performed on a 16-slice multi-detector row CT scanner, with voltage of 120–140 kV, 160–240 mA, no intravenous contrast medium agents was used, the ^{18}F-FDG was synthesized by our hospital, the pH value range was controlled between 4.5 and 8.5, radiochemical purity was >98%. The patients fasted more than 4 h, before the scan, blood was drawn to determine that the glucose level was <6.5 mmol/L, ^{18}F-FDG was injected into the cubital vein, the FDG amount injected was 5.55 MBq/kg, the fasting pelvis to neck PET/CT imaging (including CT imaging scan and PET emission scan) was conducted after 60 ± 10 min of rest, the patient was instructed to breathe slowly, 6 ± 1 beds were scanned (each bed for 3 min at an interval of 25 ± 5 min), and the pre-prepared mixture of milk and Diatrizoate Meglumine (10 ml/Kg, Diatrizoate Meglumine titrated to a final concentration of approximately 1 g/100 ml) was consumed within 5 min. Immediately following, the local stomach area PET/CT scan (scanning two beds below the top of the diaphragm with 3D, each bed for 3 min) was conducted, a Xeleris Functional Imaging Workstation (US, 2006) was used. The cross-sectional, sagittal, coronal, and fused images were obtained by the iterative reconstruction method after attenuation correction, with a slice thickness of 5 mm.

2.3. Imaging and data analysis

The obtained fused images were read by two highly experienced radiologists, with 25 years' and 20 years' experience, respectively, and they both had 5 years' experience in PET/CT diagnostic work, they employed visual analysis and semi-quantitative analysis. The diagnostic criteria for malignancy were: typical positive imaging findings, focal stomach wall SUV_{max} (the maximal standardized uptake value) ≥ 3.5 and gastric wall thickness ≥ 6.0 mm; atypical positive imaging, gastric parietal focal $SUV_{max} \geq 3.5$ but the CT images showing no specific morphological changes of the gastric wall, gastric wall thickness ≥ 6.0 mm but the stomach focal uptake $SUV_{max} < 3.5$. The atypical positive phenomenon was diagnosed by a combination of image features (i.e., the stomach wall FDG uptake near the lesion), clinical history, and related examinations. The diagnostic criteria for non-malignant lesions were: no thickening of the stomach wall via CT imaging, and SUV_{max} at the focal stomach wall <3.5.

Pathological diagnosis was confirmed by two highly experienced pathologists, with 23 years' and 30 years' experience, respectively, they were blinded to the PET/CT results, if the diagnosis of malignancy differed between pathologists, a comprehensive pathological diagnosis was given only after discussion between the two.

Table 1
Patient characteristics.

Characteristic	No. of patients
Age (mean ± SD, 65.0 ± 10.1 years)	
Gender	
Male	47
Female	21
Gastric malignancies	56
Gastric cancer	53
Adenocarcinoma	51
Signet-ring cell carcinoma	2
Carcinoid	1
Non-Hodgkin's lymphoma	2
T stage (TNM classification)	
Tis	1
T1	2
T2	21
T3	24
T4	8
Gastric benign and malignant potential lesion	12
Gastritis	11
Severe atypical hyperplasia	1

2.4. Statistical analysis

SPSS software (version 17.0 for Windows) was used for statistical analysis. The difference between data from the two PET/CT scans was analyzed via the nonparametric Wilcoxon method. We used the Mann–Whitney test to determine the SUV_{max} difference between non-malignant gastric lesions and malignant lesions. The SUV_{max} for the diagnosis of gastric cancer was analyzed by a receiver operating characteristic curve (ROC). All quantitative data were expressed as mean ± standard deviation ($x \pm s$). A P value < 0.05 was considered statistically significant.

3. Results

Ultimately, the study included 68 patients, 56 neoplasms were confirmed (male: 37, female: 19; age: 41–87 years (mean ± SD: 65.0 ± 10.1 years), 12 patients were gastric benign and malignant potential lesion (Table 1). The mean volume of milk with Diatrizoate Meglumine used was 650.0 ± 74.7 ml (mean ± SD). The mean time of first PET/CT scan after injection was 60.2 ± 8.5 min, the mean time of second PET/CT scan after injection was 85.1 ± 9.1 min.

3.1. Differences in diagnosis accuracy

Fasting ^{18}F-FDG PET/CT imaging found 55 cases of patients with positive gastric cancer and 13 cases of non-malignant lesions. Of the 55 cases diagnosed as malignant, three were false-positives. Of the 13 cases diagnosed as non-malignant lesion, four were false-negatives. Compared with pathological diagnosis and follow-up,