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Utility of 2-[^{18}F] fluoro-2-deoxy-D-glucose positron emission tomography and positron emission tomography/computed tomography imaging in the preoperative staging of head and neck squamous cell carcinoma

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Summary The combination of ^{18}F-fluorodeoxyglucose (FDG) positron emission tomography (PET) and computed tomography (CT) has been reported to be more accurate than CT or PET alone in a preoperative setting. We compared the diagnostic utility of preoperative PET/CT, PET and CT/MRI in 167 patients with newly diagnosed head and neck squamous cell carcinoma (HNSCC), of whom 104 underwent FDG PET and 63 underwent combined PET/CT with all receiving CT/MRI. These preoperative PET, PET/CT, and CT/MRI results were reviewed and their accuracies were compared in patients in whom diagnosis was confirmed histopathologically. Age, sex, primary sites and stage, and nodal involvement were comparable between two groups. The accuracy of PET and PET/CT for detecting primary tumors and cervical metastases was comparable, but significantly higher than that of CT/MRI (98%–97% vs. 86–88% for primary; 92%–93% vs. 85%–86% for neck on a level-by-level basis; $P < .05$). PET and PET/CT gave false negative results: in 2 (2%) and 2 (3%) patients for primary tumors; in 6 (6%) and 3 (5%) patients for neck metastases, respectively. PET and PET/CT also gave false-positive results for cervical

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metastases in 5 (5%) and 4 (6%) patients, respectively. Compared with PET alone, preoperative FDG PET/CT may not yield significantly improved diagnostic accuracy in patients with HNSCC. Moreover, despite their high accuracy, PET and PET/CT may not abrogate the need for conventional imaging and pathologic staging based on primary resection and neck dissection.

Introduction

The occurrence of regional metastases significantly affects the prognosis of patients with head and neck cancer, making accurate staging crucial for selecting appropriate treatment and surgery. Present noninvasive staging techniques include clinical examination, computed tomography (CT), and magnetic resonance imaging (MRI). CT and MRI, however, rely on certain criteria, such as node size and contrast-enhanced patterns, which are not very specific. The calculated sensitivity of these imaging modalities for detecting lymph node metastases ranges from 36% to 94%, whereas the reported specificity ranges from 50% to 98%.[1]

There is growing evidence that positron emission tomography (PET) with ^{18}F-fluorodeoxyglucose (FDG) is superior to conventional imaging work-ups in the evaluation of patients with head and neck malignancies.[2–5] However, the poor spatial resolution of PET is particularly limiting within the intricate anatomy of the head and neck, thus hindering localization of FDG uptake. Combined PET/CT scanners overcome these limitations by fusing the anatomic data of CT with the functional data of PET.[6,7] The combination of PET and CT has been reported to be more accurate than either alone in the detection and anatomic localization of head and neck cancer and thus may affect patient care.[8–10] These studies, however, were performed by comparing image data obtained from CT alone, PET alone and PET/CT before and after fusing PET and CT images and were compared with follow-up imaging or histopathology as standards of reference. Thus, the benefits of combined PET/CT over PET for initial staging and patient care were inferred but not actually demonstrated. The superiority of PET/CT may be obtained by comparing results of CT/MRI, PET, and PET/CT in different patient groups before and after introduction of PET/CT, with surgical pathology results being the reference standard. We present our use of FDG PET and PET/CT for preoperative staging of a large number of patients with newly diagnosed head and neck squamous cell carcinoma (HNSCC) and compare these results with those obtained by histologic examination.

Patients and methods

Patient population

Our study population consisted of 167 consecutive patients with untreated resectable HNSCC who underwent primary resection and neck dissection between 2001 and 2005. All patients were evaluated by CT and/or MRI and either whole-body FDG PET or combined FDG PET/CT during initial staging work-up within 1 month of surgery. Our institution introduced the combined PET/CT scanner in January 2004. Thus, the study cohort consisted of two groups: patients who underwent FDG PET ($n = 104$) and combined FDG PET/CT ($n = 63$) (Table 1). Patients with non-squamous cell carcinoma, unrespectable tumors, or distant metastases, and patients who had a history of prior head and neck cancer or received chemoradiotherapy prior to surgery were excluded from this study. This study was reviewed and approved by the ethics committee of our institution.

Imaging

All patients were imaged with either PET (group A) with an ECAT HR + scanner (Siemens/CTI, Knoxville, TN) or combined PET/CT (group B) with a Biograph Sensation 16 scanner (Siemens/CTI). The PET scanner provides an in-plane spatial resolution of 4.5-mm and an axial field view of 15.5 cm. Patients were required to fast for 6 h prior to scanning, and whole-body PET scanning from the skull base to the upper thighs was performed approximately 1 h after an intravenous injection of 555 MBq of FDG. PET imaging was performed using 2D mode in six or seven bed positions with 6 min of emission and 4 min of transmission. PET images were reconstructed using a ^{68}Ge source for attenuation correction with the OSEM algorithm (2 iterations, 16 subsets) and 6.0 mm Gaussian filter using a 128×128 matrix. PET/CT imaging was obtained by reconstruction of helical CT scans and PET images. The PET/CT scanner provides an in-plane spatial resolution of 6.0-mm, an axial field view of 16.2 cm, and three-dimensional image acquisition. Whole-body CT scanning was performed in spiral mode with 100 mAs, 120 kV, a section width of 5 mm, 0.75 mm collimation, and a table feed of 15 mm/gantry rotation, immediately preceding the acquisition of PET emission data (2 min per bed position). PET images were reconstructed using CT data for attenuation correction with the OSEM algorithm (2 iterations, 16 subsets) and 6.0 mm Gaussian filter using a 128×128 matrix.

As a separate staging work-up, the CT of the head and neck was performed with either on a LightSpeed QX/i scanner (GE Medical Systems, Milwaukee, WI) or a Somatom Sensation 16 (Siemens Medical Solutions, Forchheim, Germany) with a slice thickness of 3–5 mm. CT was performed on 149 patients in the supine position with contrast-enhanced axial images parallel to the occlusal line from the skull base to the upper chest. In selected patients, direct coronal or coronal reconstruction images were also obtained. MRI was performed in 48 patients with a 1.5-T unit (Achieva Release 1.0; Philips Medical Systems, Best, the Netherlands) using spin-echo technique and a slice thickness of 4 or 5 mm. Unenhanced T1-weighted images were acquired in