Importance of combined use of preoperative ^{18}F-FDG PET/CT imaging and intraoperative ^{18}F-FDG handheld gamma probe detection in recurrent papillary thyroid cancer

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Abstract
Radio-guided surgery using an intra-operative positron emission tomography (PET) probe in recurrent thyroid cancer (RTC) can be a useful method for tumor localization, verification of complete excision and to decrease operation time. We describe a case of RTC whose serum thyroglobulin (Tg) level was 5.6ng/mL. Preoperative fluorine-18-fluorodeoxyglucose positron emission tomography/computed tomography (^{18}F-FDG PET/CT) revealed two focal abnormalities in the anterior tracheal and right upper mediastinal regions and a handheld gamma probe was used intraoperatively to identify the hot areas seen on PET scan. Postoperative ^{18}F-FDG PET/CT imaging after tumor excision was normal. This case shows that recurrent tumor can be localized correctly using ^{18}F-FDG PET/CT and a surgical gamma probe.

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Introduction

Papillary thyroid cancer is the most common cancer of the thyroid gland and usually has a good prognosis. One of the most important complications is recurrences and metastases seen in the postoperative period and re-surgical treatment is preferred in these situations [1]. In these patients, the operation was more difficult due to adhesions and fibrous tissue in the previous operation site, and the risk of postoperative hypoparathyroidism and recurrent laryngeal nerve damage was also increased [1, 2]. In this respect, it is important to determine the localization of recurrent tumors and metastases. In approximately 20% of patients, the iodine-131 (^{131}I) whole-body scan (WBS) may be false negative [3]. Although preoperative fluorine-18-fluorodeoxyglucose positron emission tomography/computed tomography (^{18}F-FDG PET/CT) is a functional method, intraoperative handheld gamma probe may provide more accurate results as it makes direct contact with the lesion [4].

Case presentation

A 45-year-old male patient underwent total thyroidectomy and central neck dissection due to a malignant nodule in the right lobe. Histopathological examination revealed an 18mm follicular variant high-grade papillary thyroid cancer with extrathyroidal extension, lymphovascular invasion, and no central lymph node involvement (T1N0M0). When the postoperative serum thyroid stimulating hormone (TSH) concentration was determined as >100mU/L, 3700MBq ^{131}I dose was applied for ablation. In the post-therapeutic ^{131}I WBS performed six days after the first radioactive iodine treatment (RAI), intense activity was observed in the thyroid bed. Subsequently, we began thyroxine replacement treatment. In the 6th month follow-up, the patient had withdrawn thyroxine for 6 weeks. When his serum TSH concentration was >100mU/L, serum Tg level was 6.2ng/mL and diagnostic 185MBq ^{131}I WBS showed suspicious involvement in the thyroid site. An additional 5550MBq RAI was implemented. Afterward, high dose ^{131}I whole-body radioiodine scanning was negative and we commenced thyroxine suppression therapy.

In the first year follow-up, after the withdrawal of thyroxine hormone, ^{131}I WBS was negative while TSH concentration was >100mU/L and serum thyroglobulin level was 5.6 ng/mL. However, the high-resolution neck ultrasound (US) revealed an 8mm lesion in the anterior tracheal area (Figure 1). Ultrasound-guided fine-needle biopsy showed metastatic lesion. We used ^{18}F-FDG PET/CT scan to search for any possible metastases. Flu-

orine-18-FDG PET/CT showed two hypermetabolic focuses; one in the right upper mediastinal area (SUV=5.6), which cannot be demonstrated by the high-resolution US, and the other in the anterior tracheal area (SUV=4.8) (Figure 2A).

We started thyroxine therapy again and planned surgical treatment. One month later, while TSH concentration was 1.5 mU/L (normal range 0.4 to 4mU/L) and the free T4 level was 1.4mcg/dL (normal range 0.8 to 1.7mcg/dL) the patient was operated. Two hours before surgery, the patient was injected 370MBq ^{18}F-FDG intravenously. The hand-held gamma scintillation probe (Surgical Probe Europrobe System, France) was used intraoperatively to detect the lesions foci. Extensive central and mediastinal dissection was performed. After the resection of lesions, radioactivity was measured in the bed of the lesions to confirm the success of the dissection. The histopathological examination confirmed it to be metastatic thyroid tissues. There were no postoperative complications.

Radioactivity of the excised lesions was confirmed ex vivo both with the gamma probe and by immediate PET/CT imaging of the surgical specimen (Figure 2B). Three days after the operation, the patient was injected with 370MBq ^{18}F-FDG and re-imaging with PET/CT. No residual tissue with abnormal hypermetabolic activity was detected (Figure 2C). Six months after the operation, while the TSH concentration was >100mU/L, the serum Tg level was <0.2ng/mL.

Discussion

The majority of thyroid cancer is well differentiated. Iodine-131 or ^{123}I WBS and measurement of serum Tg level are routine methods for detecting thyroid cancer recurrence after total/near-total thyroidectomy and ^{131}I ablation [2, 4, 5]. Fluorine-18-FDG PET/CT imaging has proven value in cancer management, including thyroid cancer, generally in patients who are Tg positive/iodine negative [6]. Surgical excision is the most effective form of treatment for metastatic papillary thyroid cancer. Local recurrences require a further operation, and even for an experienced thyroid surgeon, it can be difficult to determine the localization of relapse in the operation [7]. The radio-guided surgical procedure allows the identification and removal of a small tissue area marked with a radioactive isotope [8, 9]. We used previously technetium-99m (^{99m}Tc) HYNIC-TATE successfully for radio-guided surgery of recurrent medullary thyroid cancer [10].

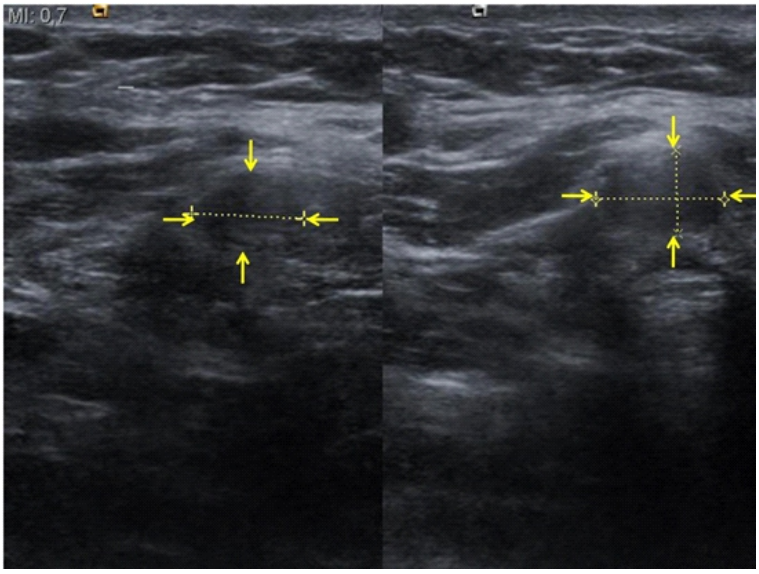

Figure 1. The high-resolution neck ultrasound revealed an 8 mm lesion in the anterior tracheal area.

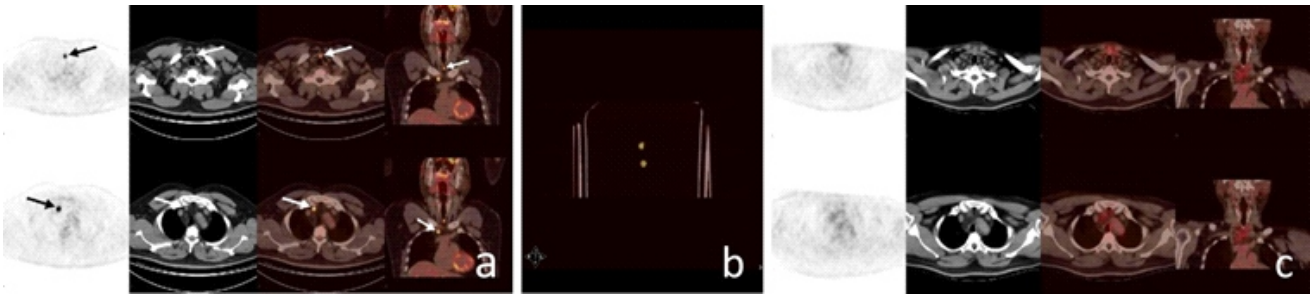

Figure 2. a) ^{18}F-FDG PET/CT showed two discrete hypermetabolic focus. b) Radioactivity of the excised lesions was confirmed ex vivo both with the gamma probe and by immediate PET/CT imaging of the surgical specimen. c) PET/CT demonstrating no residual sites of abnormal hypermetabolic activity verifying adequate excision.

In the current case, the ^{18}F-FDG PET/CT achieved to detect the unknown lesion which is not seen by ultrasonography. It would be an ineffective procedure in which case the excision of one metastatic lesion detected by US and verified histopathologically. Detection of another metastatic lesion with ^{18}F-FDG PET/CT and using of gamma probe supported the immediate resection of whole lesions.

The authors declare that they have no conflicts of interest.

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