This is a non-final version of an article published in final form in *Nuclear Medicine Communications*

October 1, 2014 [Epub ahead of print]

***Nuclear Medicine Communications* website:**

http://journals.lww.com/nuclearmedicinecomm/pages/default.aspx

A comparison between ^{11}C-methionine PET/CT and MIBI SPECT/CT for localization of parathyroid adenomas/hyperplasia

Nobuyuki Hayakawa[a], Yuji Nakamoto*[a], Kensuke Kurihara[a], Akihiro Yasoda[b], Naotetsu Kanamoto[b,c], Masako Miura[b,d], Nobuya Inagaki[b], Kaori Togashi[a]

Running head: ^{11}C-methionine PET/CT vs. MIBI SPECT/CT for hyperparathyroidism

Affiliation

[a]Department of Diagnostic Imaging and Nuclear Medicine, Kyoto University Graduate School of Medicine, 54 Shogoin-kawahara-cho, Sakyo-Ku, Kyoto 606-8507 Japan

[b]Department of Diabetes, Endocrinology and Nutrition, Kyoto University Graduate School of Medicine, 54 Shogoin-kawahara-cho, Sakyo-Ku, Kyoto 606-8507 Japan

[c]Department of Endocrinology, Osaka City General Hospital, 2-13-22 Miyakojima-hondori, Miyakojima-ku, Osaka 534-0021 Japan

[d]Department of Endocrinology, Rakuwakai Otowa Hospital, 2 Otowa-chinji-cho, Yamashina-ku, Kyoto 606-8062 Japan

***Corresponding author**

Yuji Nakamoto, MD, PhD

Department of Diagnostic Imaging and Nuclear Medicine, Kyoto University Graduate School of Medicine, 54 Shogoin-kawahara-cho, Sakyo-Ku, Kyoto 606-8507 Japan

E-mail address: ynakamo1@kuhp.kyoto-u.ac.jp

Phone. +81-75-751-3761 Fax. +81-75-771-9709

Financial disclosure: none

Data presented previously at Society of Nuclear Medicine and Molecular Imaging's (SNMMI) annual meeting and published as abstract in J Nucl Med. 2013; 54 (Supplement 2):142

Abstract

Objective The purpose of this study was to compare the sensitivity of single photon emission computed tomography/computed tomography (SPECT/CT) using ^{99m}Tc-sestamibi (MIBI) with that of positron emission tomography/computed tomography (PET/CT) using ^{11}C-methionine (MET) for localization of parathyroid adenomas/hyperplasia in primary hyperparathyroidism.

Materials and Methods Twenty-three patients with primary hyperparathyroidism were analyzed. Fifteen patients underwent surgery, and the remaining eight patients didn't undergo surgery, but were clinically diagnosed as primary hyperparathyroidism. Patients underwent both MET PET/CT and MIBI SPECT/CT scanning. The sensitivities of both modalities were evaluated on a per-patient basis, and a per-lesion basis for parathyroid lesions detected by surgery. The size of the parathyroid adenoma/hyperplasia and serum intact parathyroid hormone (PTH) levels were compared with the results of each of the two modalities.

Results Per-patient sensitivities of MET PET/CT and MIBI SPECT/CT were 65% and 61%, respectively. Per-lesion sensitivities of MET PET/CT and MIBI SPECT/CT were 91% and 73% for histologically-confirmed adenomas, and 30% and 30% for hyperplastic glands, respectively. No significant differences were observed between the two modalities. The size of uptake-positive lesions was significantly larger than that of uptake-negative lesions in both modalities. Intact PTH levels showed no significant difference between uptake-positive and uptake-negative patients in both modalities.

Conclusions The sensitivities of MET PET/CT and MIBI SPECT/CT were comparable. MET PET/CT would have a complementary role in localizing parathyroid adenomas/hyperplasia when MIBI SPECT/CT is inconclusive.

Keywords

Methionine; PET/CT; Positron-Emission Tomography; Technetium Tc 99m Sestamibi; SPECT/CT, Tomography, Emission-Computed, Single-Photon; Hyperparathyroidism

Introduction

Preoperative localization of parathyroid adenomas/hyperplasia is mandatory for minimally invasive surgery or unilateral neck exploration. Localization techniques include functional and anatomical methods. Among the functional methods, dual phase parathyroid scintigraphy using ^{99m}Tc-sestamibi (MIBI) is one of the most common. Single-photon emission computed tomography using MIBI (MIBI SPECT), has been shown to be more sensitive and allows for more precise localization than planar scintigraphy [1, 2]. It is also reported that hybrid imaging, which combines SPECT with computed tomography (SPECT/CT), contributes to surgical planning by adding anatomical information, especially in patients with ectopic adenomas or with previous neck surgery [3]. A higher sensitivity of MIBI SPECT/CT compared with MIBI SPECT or planar scintigraphy has also been reported [4].

Recently, studies have explored the utility of positron emission tomography using ^{11}C-Methionine (MET PET) for localization of parathyroid adenomas. According to a recent meta-analysis, which included nine studies comprising 258 patients, the pooled per-patient sensitivity was 81% [5]. In addition, Weber *et al.* showed high accuracy of MET PET/CT in the preoperative localization of parathyroid adenomas in a large series of cases of primary hyperparathyroidism [6], although Herrmann *et al.* described much lower sensitivity of MET PET in their retrospective analysis [7]. Recently, Schalin-Jäntti *et al.* compared the performance of MET PET/CT and MIBI SPECT /CT in hyperparathyroidism along with ^{123}I/MIBI scintigraphy and selective venous sampling [8]. However, their patient population was limited to previously operated patients with persistent hyperparathyroidism before reoperation. To the best of our knowledge, there are few reports directly comparing MET PET/CT and MIBI SPECT/CT performed in a patient group with hyperparathyroidism, not restricted to persistent hyperparathyroidism after operation.

The purpose of this study was to compare the performance of MET PET/CT and MIBI SPECT/CT for localizing parathyroid adenomas/hyperplasia.

Materials and Methods

Patients

From July 2009 to August 2013, 23 patients (19 females, 4 males, age range 32–83 years) underwent both MET PET/CT and MIBI SPECT/CT for suspected primary hyperparathyroidism, fulfilling at least one of the following criteria: 1) parathyroid adenoma or hyperplasia was confirmed surgically (n = 15) , or 2) increased serum intact PTH level (> 65 pg/mL), increased serum calcium level (> 9.9 mg/dL in 2009–2011, > 10.1 mg/dL in 2012–2013) and fractional excretion of calcium > 0.01 (n = 8). This study was approved by the ethics committee in our institute, and written informed consent was obtained from all participants.

MET PET/CT scan

PET/CT scanning was performed using a combined PET/CT scanner (Discovery ST Elite®; GE Healthcare, Waukesha, WI, USA). This system integrates a PET scanner with a multidetector-row CT scanner (16 detectors). PET/CT scanning was performed at 15–34 minutes (mean 26 minutes) after intravenous injection of 441 to 906 MBq of ^{11}C-methionine. The scanning range was from neck to thorax.

MIBI scintigraphy and SPECT/CT scan

SPECT/CT was performed using a SPECT/CT scanner (Infinia Hawkeye 4®, GE Healthcare). This system incorporates a dual head gamma camera and integrated low-dose, 4-slice CT. Patients were injected intravenously with approximately 600MBq of ^{99m}Tc-MIBI. Anterior planar images from neck to thorax were acquired at 15 minutes (early images) and 2–3 hours (delayed images) after injection. SPECT/CT images were acquired from neck to thorax after acquisition of delayed planar images.

Image interpretation

Interpretations of PET images were performed by consensus of at least two board-certified nuclear medicine physicians blinded to clinical information including other clinical images and serum intact PTH levels. MIBI planar images were available for interpretation of MIBI SPECT/CT. In addition, interpretations of 1) only planar images 2) SPECT + planar images of MIBI scintigraphy were also recorded. MET PET/CT and MIBI SPECT/CT images were interpreted visually. A focus of increased uptake located adjacent to the thyroid gland or in the mediastinum was considered positive for abnormal parathyroid gland. Focal uptake detectable only in early planar imaging of MIBI scintigraphy was not considered parathyroid uptake. Multiple foci of increased uptake in the mediastinum in MET PET/CT images were regarded not as parathyroid lesions but as lymph nodes, because inflammatory changes often cause focal uptakes of MET in mediastinal and hilar lymph nodes [9].

Standard of reference

In per-patient analysis, if MET PET/CT or MIBI SPECT/CT detected at least one positive lesion (on the correct side if the location was confirmed by surgery), the results were considered true-positive. If no positive lesion was observed, the results were considered false-negative.

In per-lesion analysis, only patients who underwent surgery were analyzed. If MET PET/CT or MIBI SPECT/CT could locate adenomas/hyperplastic glands on the correct side or other specific location (if ectopic), the results were considered true-positive. If no abnormal uptake was observed in the same location, the results were considered false-negative.

Statistical analysis

The sensitivities of MET PET/CT and MIBI SPECT/CT in per-patient and per-lesion analysis were calculated and compared using McNemar's chi-squared test. For patients who underwent surgery, we compared the adenoma/hyperplastic glands' length and volume calculated as (length × width × height) × $\pi/6$ obtained from pathological specimens between positive and negative lesions in each modality using the unpaired *t*-test and Mann-Whitney U-test. For all patients, the serum intact PTH levels were also compared between patients with and without positive lesions in each modality using the Mann-Whitney U-test.

In each analysis, a *P* value of less than 0.05 was considered statistically significant.

Results

Sensitivity of MET PET/CT and MIBI SPECT/CT

Patients' characteristics and findings are summarized in Table 1. Of 15 patients who underwent surgery, 11 single adenomas, including one mediastinal adenoma in patient # 8, were confirmed in 11 patients, and 10 hyperplastic parathyroid glands were confirmed in three patients, including two patients with suspected multiple endocrine neoplasia type 1 (MEN 1) (patients #13 and 15). In one patient, histological and clinical findings could not distinguish between adenoma and hyperplasia. This patient (patient #12) had been diagnosed with MEN 1 and suffered from recurrent hyperparathyroidism after total parathyroidectomy for parathyroid hyperplasia. Eight patients were clinically diagnosed with primary hyperparathyroidism, but did not undergo surgery.

Table 2 summarizes the sensitivities of MET PET/CT and MIBI SPECT/CT in a per-patient analysis and in a per-lesion analysis. The sensitivities of MET PET/CT and MIBI SPECT/CT were 65% and 61%, respectively, on a per-patient basis, and no significant difference was found between the two methods (McNemar's chi-squared test). The numbers of detected lesions were the same between the three manners of interpretation of MIBI scintigraphy, namely, using only planar images, MIBI SPECT + planar image, or MIBI SPECT/CT + planar images. Table 3 shows the cross-tabulation of the results of MET PET/CT and MIBI SPECT/CT studies. A MET-positive, MIBI-negative case and a MET-negative, MIBI positive case are shown in Figures 1 and 2, respectively.

The sensitivities of MET PET/CT and MIBI SPECT/CT for histologically-confirmed adenomas and multiple hyperplastic glands were 91% and 73%, and 30% and 30%, respectively, without a statistically significant difference (McNemar's chi-squared test).

Lesion size and intact PTH levels according to the results of MET PET/CT, MIBI-SPECT/CT

The long-axis lengths and calculated volumes of uptake-positive lesions were significantly larger than those of uptake-negative lesions in MET PET/CT (unpaired *t*-test for length and Mann–Whitney U-test for calculated volume). No significant difference was found in intact PTH levels between MET PET/CT positive and negative patients (Mann–Whitney U-test) (Table 4).

The same analysis was performed on MIBI SPECT/CT results. Similar to the results of MET PET/CT, uptake-positive lesions were larger than uptake-negative lesions. No significant difference was observed in intact PTH levels between MIBI SPECT/CT uptake-positive and uptake-negative patients (Table 5).

Discussion

In per-patient and per-lesion analyses, the sensitivities of MET PET/CT were comparable to those of MIBI SPECT/CT for parathyroid gland pathology. To the best of our knowledge, the present study is the first study directly comparing MET PET/CT with MIBI SPECT/CT in patients with primary hyperparathyroidism, not restricted to persistent hyperparathyroidism before operation. There have been a few previous reports comparing MET PET or PET/CT with MIBI SPECT; it has been controversial whether PET or PET/CT using MET is superior to MIBI SPECT. In the study by Tang *et al.* comparing MET PET/CT with MIBI SPECT in 30 preoperative patients with primary or secondary hyperparathyroidism, MET PET/CT showed comparable sensitivity to MIBI SPECT [10]. They reported that the sensitivities of MET PET/CT and MIBI SPECT were 92% and 95%, respectively, for adenoma, and 68% and 59%, respectively, for hyperplasia. Otto *et al.* reported the superiority of MET PET compared with MIBI SPECT for primary hyperparathyroidism related to adenoma or carcinoma, with sensitivities of MET PET and MIBI SPECT of 94% and 50%, respectively [11]. Herrmann *et al.* reported the sensitivity of MET PET (53%) was lower than that of MIBI SPECT (74%) for prediction of lesions to correct side in patients with hyperparathyroidism [7]. In this investigation, the sensitivities of MET PET/CT and MIBI SPECT/CT were comparable, and MET PET/CT had a complementary role in detection.

MIBI SPECT/CT did not detect additional lesions compared with MIBI SPECT or planar imaging in any cases, although MIBI SPECT/CT allowed more detailed localization in one patient with an ectopic parathyroid gland. The comparison between MIBI SPECT/CT and SPECT is consistent with Gayed's report, demonstrating MIBI SPECT/CT had no additional value over conventional MIBI SPECT imaging except for localization of ectopic parathyroid glands [12]. In contrast, Kim *et al.* found higher sensitivity of MIBI SPET/CT compared with MIBI SPECT, dual-phase MIBI scintigraphy, and conventional imaging [4]. Although it is controversial whether SPECT/CT has higher sensitivity than SPECT, SPECT/CT may be recommended when an ectopic parathyroid gland is suspected. In addition, SPECT/CT has advantages for patients with previous thyroid or parathyroid surgery, with multiglandular disease, or with nodular thyroid disease, and it improves interobserver agreement [3, 13]. Our results are inconsistent with the previous reports showing higher sensitivities of SPECT or SPECT/CT than those of planar imaging [1, 2, 14, 15]. Although the reason for this is unclear, SPECT is theoretically considered to have an advantage over planar imaging by providing detailed information concerning a three-dimensional location [14].

Five patients showed MET-positive/MIBI-negative results and four patients showed MET-negative/MIBI-positive results, indicating these two modalities play a complementary role. MET PET/CT showed positive results in 56% (5/9) of patients who showed negative results in MIBI SPECT/CT. Therefore, MET PET/CT would be a feasible option if MIBI-negative results are obtained in localization of adenomas/hyperplasia. Such complementary results were also observed in a previous report [10]. Incorporation into parathyroid hormone and its precursors is considered to be one of the mechanisms of ^{11}C-methionine uptake into adenomas/hyperplasia, while MIBI uptake is considered to be positively related to increased concentrations of mitochondria-rich oxyphil cells and negatively related to the expression of p-glycoprotein, or multidrug resistance related protein [16]. Such different mechanisms of tracer uptake may account for their complementary role in localizing parathyroid gland adenomas/hyperplasia.

Positive lesions in both modalities were larger than negative lesions in the present study. The correlation between lesion detectability in both modalities and lesion size or weight was observed in previous reports [17–19]. Only three (38%) and one (13%) of eight lesions less than 276 μL could be detected by MET PET/CT and MIBI SPECT/CT, respectively. In contrast, both modalities depicted nine (90%) of ten lesions equal to or larger than 276 μL.

One possible factor affecting MET and MIBI uptake is the intact PTH level. There is a previous report showing positive correlation between MET uptake of the lesion and serum intact PTH level [11]. Per-patient sensitivities of both modalities were 100% in six patients with intact PTH levels > 150 pg/mL in our population. However, no significant difference in intact PTH levels was observed between positive and negative cases in both modalities, which is consistent with a previous report by Weber *et al*.[6].

Higher sensitivities of MET PET or PET/CT compared with our study (65% in per-patient) have been reported in several previous studies. In a meta-analysis in which nine studies were included, Caldarella *et al.* reported the pooled sensitivity in patients with suspected parathyroid adenoma was 81% [5]. Weber *et al.* recently reported a sensitivity of MET PET/CT of 90.1% for localization of parathyroid adenomas/hyperplasia in 102 preoperative patients with primary hyperparathyroidism [6]. Conversely, Herrmann *et al.* reported lower sensitivity (54%) of MET PET in 41 patients with suspected hyperparathyroidism, validating PET findings by histological or clinical findings [7]. In the present study, as Herrmann *et al.* reported, patients were not necessarily scheduled to have surgery, and such a difference in population might account for different results from other previous reports showing higher sensitivities of MET PET or PET/CT. In three patients who showed no abnormal uptake with either modality, no parathyroid lesion was detected with other imaging modalities. These patients may have parathyroid lesions too small to be detected by diagnostic imaging. Per-patient sensitivity of MET PET/CT in patients who underwent surgery was higher (80%). However, this result may contain a bias because MET PET/CT and MIBI SPECT/CT results themselves might influence clinical management (i.e. surgical or medical therapy).

Dual-tracer parathyroid scintigraphy using pinhole collimator has been demonstrated to allow more accurate localization of parathyroid lesions compared with single-tracer, dual phase protocol with or without pinhole collimator or SPECT [20-22]. Especially, accurate localization of parathyroid lesions using this technique has been shown in multiple parathyroid gland disease [23], in which the sensitivities of both MET PET/CT and MIBI SPECT/CT were insufficient in the present study. Therefore, this technique might have detected more parathyroid lesions, if it had been performed. Comparison between dual-tracer scintigraphy and MET PET or PET/CT has not been fully investigated, though Schalin-Jäntti *et al.* reported comparable accuracy of these techniques in reoperative setting of primary hyperparathyroidism [8].

There are several limitations in the present study. First, histological confirmation was not obtained in all of the lesions. Therefore, it is possible that positive findings in some patients who did not undergo surgery were false-positive. However, we believe the possibility for false-positive cases is low, because suspected enlarged parathyroid glands were detected by ultrasonography corresponding to MET or MIBI uptakes in such patients. Second, a relatively small number of patients were analyzed in this investigation. Finally, we used only delayed SPECT/CT without obtaining early SPECT/CT. There is one article demonstrating higher sensitivity of early SPECT/CT [14], and different results might have been acquired with utilization of early SPECT/CT.

In conclusion, the sensitivities of MET/PET CT and MIBI SPECT/CT were comparable in localizing parathyroid adenomas/hyperplasia in patients with primary hyperparathyroidism. Although the sensitivities of both modalities were not satisfactory in this investigation, these two modalities may play complementary roles. MET PET/CT would be a feasible option if negative results are obtained in conventional parathyroid scintigraphy using MIBI.

References

1. Slater A, Gleeson FV. Increased sensitivity and confidence of SPECT over planar imaging in dual-phase sestamibi for parathyroid adenoma detection. *Clin Nucl Med* 2005; **30**:1–3

2. Lorberboym M, Minski I, Macadziob S, Nikolov G. Incremental diagnostic value of preoperative ^{99m}Tc-MIBI SPECT in patients with a parathyroid adenoma. *J Nucl Med* 2003; **44**:904–908.

3. Krausz Y, Bettman L, Guralnik L, Yosilevsky G, Keidar Z, Bar-Shalom R, *et al.* Technetium-99m-MIBI SPECT/CT in primary hyperparathyroidism. *World J Surg* 2006; **30**:76–83

4. Kim Y-I, Jung YH, Hwang KT, Lee H-Y. Efficacy of ^{99m}Tc-sestamibi SPECT/CT for minimally invasive parathyroidectomy: comparative study with 99mTc-sestamibi scintigraphy, SPECT, US and CT. *Ann Nucl Med* 2012; **26**:804–810

5. Caldarella C, Treglia G, Isgrò MA, Giordano A. Diagnostic performance of positron emission tomography using ^{11}C-methionine in patients with suspected parathyroid adenoma: a meta-analysis. *Endocrine* 2013; **43**:78–83

6. Weber T, Maier-Funk C, Ohlhauser D, Hillenbrand A, Cammerer G, Barth TF, *et al.* Accurate preoperative localization of parathyroid adenomas with C-11 methionine PET/CT. *Ann Surg* 2013; **257**:1124–1128

7. Herrmann K, Takei T, Kanegae K, Shiga T, Buck AK, Altomonte J, *et al.* Clinical value and limitations of [^{11}C]-methionine PET for detection and localization of suspected parathyroid adenomas. *Mol Imaging Biol* 2009; **11**:356–363

8. Schalin-Jäntti C, Ryhänen E, Heiskanen I, Seppänen M, Arola J, Schildt J, *et al.* Planar scintigraphy with ^{123}I/^{99m}Tc-sestamibi, ^{99m}Tc-sestamibi SPECT/CT, ^{11}C-methionine PET/CT, or selective venous sampling before reoperation of primary hyperparathyroidism? *J Nucl Med* 2013; **54**:739–747

9. Yasukawa T, Yoshikawa K, Aoyagi H, Yamamoto N, Tamura K, Suzuki K, *et al*. Usefulness of PET with ^{11}C-methionine for the detection of hilar and mediastinal lymph node metastasis in lung cancer. *J Nucl Med* 2000; **41**:283-290.

10. Tang B-N-T, Moreno-Reyes R, Blocklet D, Corvilain B, Cappello M, Delpierre I, *et al.* Accurate pre-operative localization of pathological parathyroid glands using ^{11}C-methionine PET/CT. *Contrast Media Mol Imaging* 2008; **3**:157–163

11. Otto D, Boerner a R, Hofmann M, Brunkhorst T, Meyer GJ, Petrich T, *et al.* Pre-operative localisation of hyperfunctional parathyroid tissue with ^{11}C-methionine PET. *Eur J Nucl Med Mol Imaging* 2004; **31**:1405–1412

12. Gayed IW, Kim EE, Broussard WF, Evans D, Lee J, Broemeling LD, *et al.* The Value of ^{99m}Tc-Sestamibi SPECT / CT over Conventional SPECT in the Evaluation of Parathyroid Adenomas or Hyperplasia. *J Nucl Med* 2005; **46**:248–252

13. Wong KK, Fig LM, Youssef E, Ferretti A, Rubello D, Gross MD. Endocrine Scintigraphy with Hybrid SPECT/CT. Endocr Rev June 30 2014 [Epub ahead of print]

14. Lavely WC, Goetze S, Friedman KP, Leal JP, Zhang Z, Garret-Mayer E, *et al.* Comparison of SPECT/CT, SPECT, and planar imaging with single- and dual-phase ^{99m}Tc-sestamibi parathyroid scintigraphy. *J Nucl Med* 2007; **48**:1084–1089

15. Thomas DL, Bartel T, Menda Y, Howe J, Graham MM, Juweid ME. Single photon emission computed tomography (SPECT) should be routinely performed for the detection of parathyroid abnormalities utilizing technetium-99m sestamibi parathyroid scintigraphy. 2009; **34**:651–655

16. Pons F, Torregrosa JV, Fuster D. Biological factors influencing parathyroid localization. *Nucl Med Commun* 2003; **24**:121–124

17. Oksüz MO, Dittmann H, Wicke C, Müssig K, Bares R, Pfannenberg C, *et al.* Accuracy of parathyroid imaging: a comparison of planar scintigraphy, SPECT, SPECT-CT, and C-11 methionine PET for the detection of parathyroid adenomas and glandular hyperplasia. *Diagn Interv Radiol* 2011; **17**:297–307

18. Sekiyama K, Akakura K, Mikami K, Mizoguchi K-I, Tobe T, Nakano K, *et al.* Usefulness of diagnostic imaging in primary hyperparathyroidism. *Int J Urol* 2003; **10**:7–11

19. Sundin A, Johansson C, Hellman P, Bergström M, Ahlström H, Jacobson GB, *et al.* PET and parathyroid L-[carbon-11]methionine accumulation in hyperparathyroidism. *J Nucl Med* 1996; **37**:1766–1770

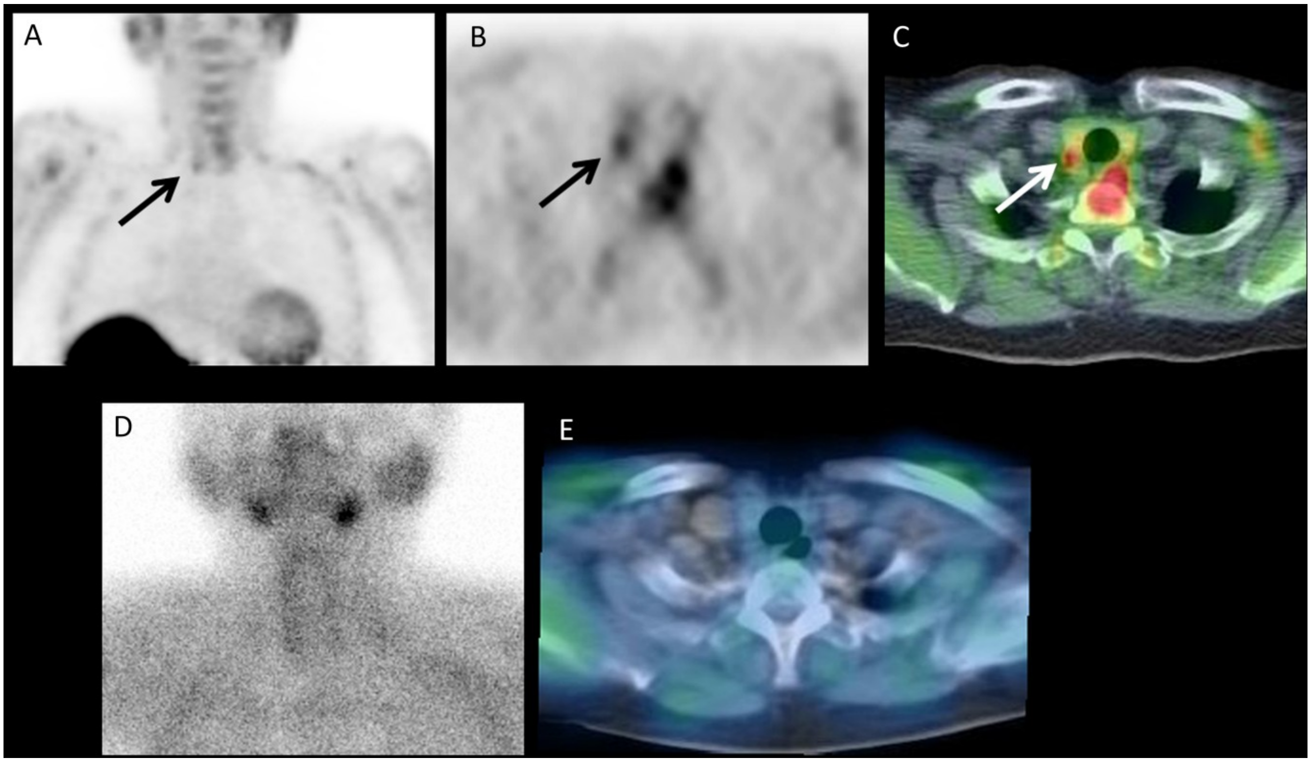
20. Caveny SA, Klingensmith WC 3rd, Martin WE, Sage-El A, McIntyre RC Jr, Raeburn C, *et al*. Parathyroid imaging: the importance of dual-radiopharmaceutical simultaneous acquisition with ^{99m}Tc-sestamibi and ^{123}I. *J Nucl Med Technol* 2012; **40**:104-110

21. Klingensmith WC 3rd, Koo PJ, Summerlin A, Fehrenbach BW, Karki R, Shulman BC, *et al*. Parathyroid imaging: the importance of pinhole collimation with both single- and dual-tracer acquisition. *J Nucl Med Technol* 2013; **41**:99-104

22. Ho Shon IA, Yan W, Roach PJ, Bernard EJ, Shields M, Sywak M, et al. Comparison of pinhole and SPECT 99mTc-MIBI imaging in primary hyperparathyroidism. *Nucl Med Commun* 2008; **29**:949-955

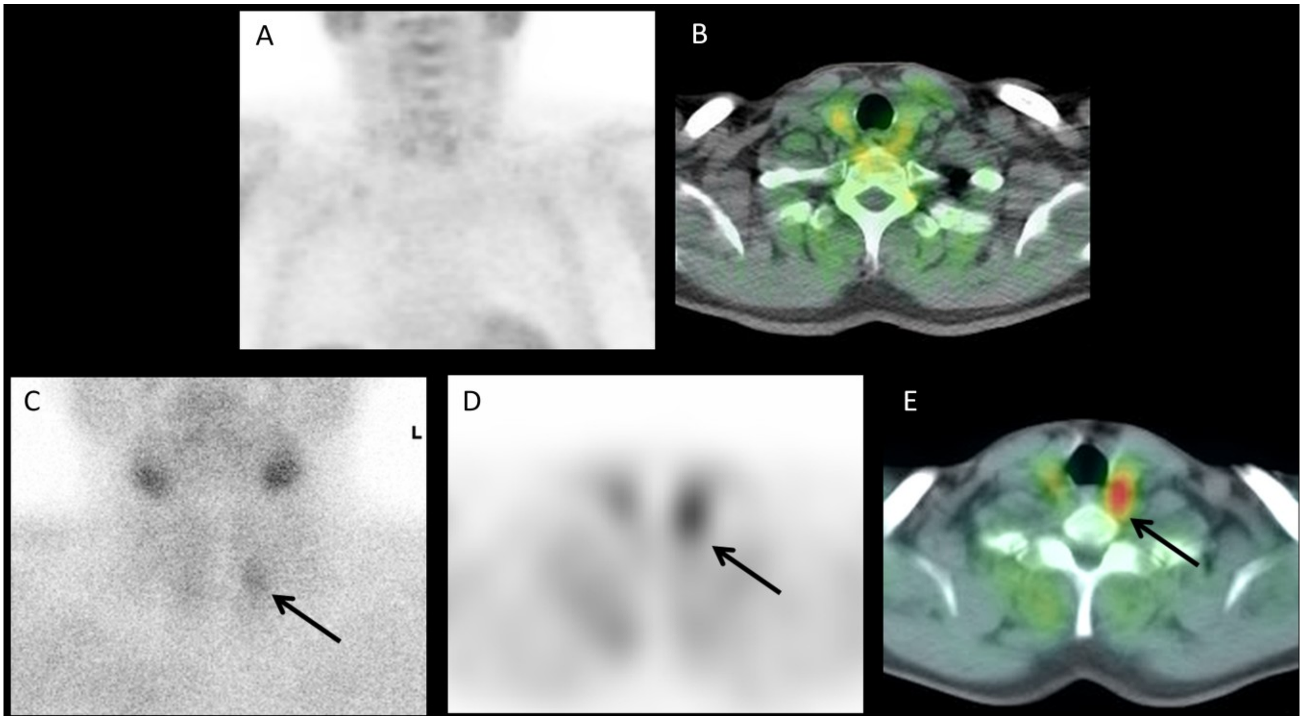
23. Hindié E, Mellière D, Jeanguillaume C, Ureña P, deLabriolle-Vaylet C, Perlemuter L. Unilateral surgery for primary hyperparathyroidism on the basis of technetium Tc 99m sestamibi and iodine 123 subtraction scanning. *Arch Surg* 2000; **135**:1461-1468.

Figure 1



MET-positive, MIBI-negative result in a 75-year-old female (Patient No. 5). An adenoma of the right lower parathyroid gland was confirmed at surgery. A MET PET maximum intensity projection image (A), an axial PET image (B) and a fusion of CT and MET PET (C) show a focus of increased uptake behind the lower pole of the right thyroid lobe (A, B: black arrow, C: white arrow). No focal uptake corresponding to the lesion is observed in a delayed planar image of MIBI scintigraphy (D), or in an axial fusion image of CT and MIBI SPECT (E).

Figure 2



MET-negative, MIBI-positive result in a 49-year-old male (Patient No. 21). An enlarged parathyroid gland was detected behind the lower pole of the left thyroid lobe by ultrasonography. A maximum intensity projection image (A) and an axial fusion image of CT and MET PET (B) show no increased uptake corresponding to the lesion. A focus of increased MIBI uptake is observed in a delayed planar image (C), an axial SPECT image (D), and in an axial fusion image of CT and MIBI SPECT (E) (black arrow).

Table 1 Patients' characteristics and scintigraphic findings

Patient No.	Sex	Age	iPTH level (pg/mL)	No. of lesions	Histology	Length (mm)	volume (μL)	No. of MET PET/CT positive lesions	No. of MIBI planar positive lesions	No. of MIBI SPECT + planar positive lesions	No. of MIBI SPECT/CT + planar positive lesions
<u>Operated cases</u>											
1	F	60	156	1	A	12	276	1	1	1	1
2	F	74	782	1	A	22	2304	1	1	1	1
3	M	48	104	1	A	20	524	1	1	1	1
4	F	54	136	1	A	24	1508	1	1	1	1
5	F	75	114	1	A	8	75	1	0	0	0
6	F	76	109	1	A	20	N/A	1	1	1	1
7	F	58	91	1	A	15	220	1	0	0	0
8	F	83	92	1	A	23	506	1	1	1	1
9	F	75	86	1	A	10	168	0	1	1	1
10	M	66	96	1	A	13	204	1	0	0	0
11	F	65	185	1	A	N/A	N/A	1	1	1	1
12	F	57	497	1	A or H	20	1843	1	1	1	1
13	F	65	120	3[a]	H	15	385	0	1	1	1
14	F	32	131	2	H	20,10	251,168	0	0	0	0
15	M	58	417	5	H	30, 25, 18, 16, 8	7603,3142, 933,151,50	3	2	2	2
<u>Non-operated cases</u>											
16	F	65	98	N/A	N/A	N/A	N/A	1	0	0	0
17	F	58	100	N/A	N/A	N/A	N/A	0	0	0	0
18	F	65	96	N/A	N/A	N/A	N/A	0	0	0	0

19	F	47	143	N/A	N/A	N/A	N/A	0	0	0	0
20	F	56	102	N/A	N/A	N/A	N/A	0	1	1	1
21	M	49	82	N/A	N/A	N/A	N/A	0	1	1	1
22	F	71	105	N/A	N/A	N/A	N/A	1	0	0	0
23	F	43	182	N/A	N/A	N/A	N/A	1	1	1	1

Abbreviations: M, male; F, female; iPTH, intact PTH; N/A, not available

[a] Two of the three hyperplastic parathyroid glands were excluded from size evaluation because they were divided into pieces after resection.

Table 2 Sensitivity of MET PET/CT and MIBI scintigraphy in per-patient and per-lesion analyses

	MET PET/CT	MIBI planar	MIBI SPECT + planar	MIBI SPECT/CT + planar	*P*[a]
All patients	65% (15/23)	61% (14/23)	61% (14/23)	61% (14/23)	NS
Patients undergoing surgery	80% (12/15)	73% (11/15)	73% (11/15)	73% (11/15)	NS
All Histologically-confirmed lesions	64% (14/22)	55% (12/22)	55% (12/22)	55% (12/22)	NS
Adenomas	91% (10/11)	73% (8/11)	73% (8/11)	73% (8/11)	NS
Hyperplastic glands	30% (3/10)	30% (3/10)	30% (3/10)	30% (3/10)	NS
Single gland lesions	92% (11/12)	75% (9/12)	75% (9/12)	75% (9/12)	NS

Abbreviations: NS, not significant

[a] MET PET/CT vs. MIBI SPECT/CT + planar

Table 3 Cross-tabulation of the results of MET PET/CT and MIBI SPECT/CT study on a per-patient basis

	MIBI-positive	MIBI-negative
MET-positive	10	5
MET-negative	4	4

Table 4. Length and volume of histologically-confirmed lesions and intact PTH levels according to the results of MET PET/CT study

	MET-positive	MET-negative	*P*
Length[a] (mm)	19.2 ± 6.0	13.2 ± 4.6	0.04
Volume[b] (μL)	728.5 (75–7603)	168 (50–385)	0.02
Intact PTH level[b] (pg/mL)	114 (91–782)	101 (82–143)	0.12

[a] mean ± standard deviation

[b] median (range)

Table 5. Length and volume of histologically-confirmed lesions and intact PTH levels according to the results of MIBI SPECT/CT study

	MIBI-positive	MIBI-negative	*P*
Length[a] (mm)	20.1 ± 5.9	13.5 ± 4.5	0.02
Volume[b] (μL)	1016 (168–7603)	186 (50–933)	< 0.01
Intact PTH level[b] (pg/mL)	128 (82–782)	100 (91–143)	0.16

[a] mean ± standard deviation

[b] median (range)